EPA WORK ASSIGNMENT NUMBER: 132-1L46
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EBASCO SERVICES INCORPORATED

ENDANGERMENT ASSESSMENT FOR THE WELLS G & H SITE WOBURN, MASSACHUSETTS

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

1.0 INTRODUCTION

The Wells G & H site, Woburn, Massachusetts, is currently the subject of a Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) being conducted by the REM III project team under contract to the United States Environmental Protection Agency (EPA).

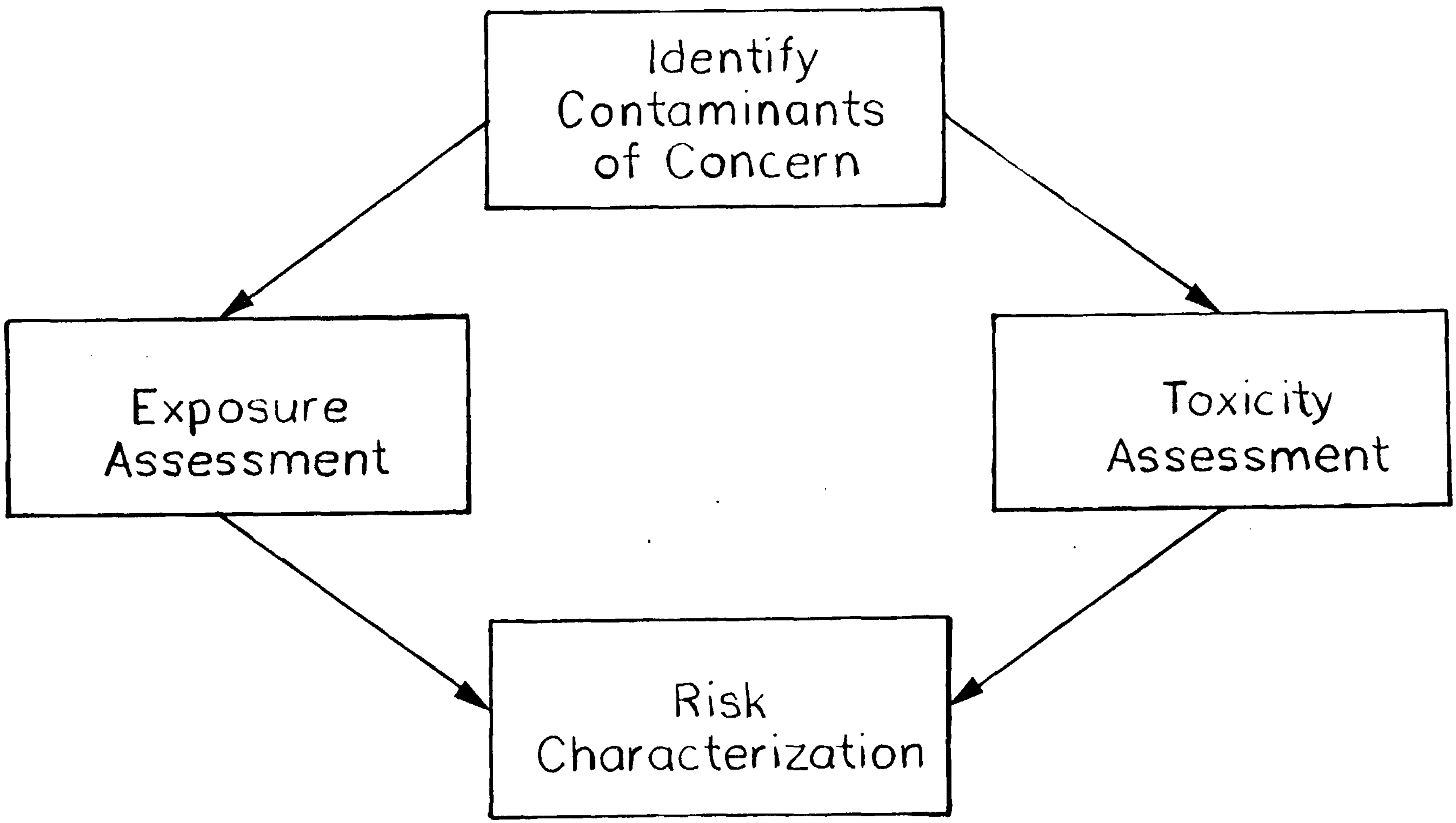
This endangerment assessment addresses the potential human health and environmental impacts associated with the Wells G & H site under the no-action alternative--that is, in the absence of remedial (corrective) action. Evaluation of the no-action alternative is required under Section 300.68(f)(v) of the National Contingency Plan (EPA 1985a). It is based on the available sampling data collected during the remedial investigation conducted by NUS Corporation and presented in reports by NUS Corporation (NUS 1986) and Alliance Technologies Corporation (Alliance 1986), and the supplemental RI/FS conducted by Ebasco Services Incorporated (Ebasco 1988a).

The methodologies used in this endangerment assessment are designed to be consistent with guidelines from the Office of Emergency and Remedial Response (EPA 1985b, 1986a) and federal guidelines for risk assessment (EPA 1986b,c,d).

The organization of this endangerment assessment is as follows. First, a brief description of the site and a summary of the site history are presented. Next, the general methodology used to evaluate exposure and risk are presented in this introductory chapter. The intent is to provide a general framework for the evaluations that are presented in the following sections. Each of the subsequent sections will focus on a potential source area (property owned by W.R. Grace and Company, New England Plastics, Olympia Nominee Trust, Unifirst Corporation, and Wildwood Conservation Corporation) and the area of the site which surrounds Wells G & H but is not acting as a direct source.

Figure 1-1 provides a flow chart of the components that will be included in the area-specific sections. The methodologies used to evaluate the properties are summarized in this chapter as well as being highlighted in the property

Figure 1-1



The Endangerment Assessment Process

specific sections. First, the chemicals of potential concern, a subset of the large number of chemicals detected in the environmental media at the site, will be selected. The methodology for the selection of the chemicals of potential concern is presented in Appendix A and summarized in Section 1.3. Exposure pathways under current- and future-use scenarios are then identified for each area. A general discussion can be found in Section 1.4. Concentrations of the chemicals of concern at exposure points are presented in the exposure assessment subsection. Risk characterization subsections follow the development of exposure point concentrations. In these subsections, numerically applicable or relevant and appropriate requirements (ARARs) are identified and compared to the exposure point concentrations. CERCLA, as amended by Congress under the Superfund Amendments and Reauthorization Act (SARA), states that ARARs include any applicable or relevant and appropriate standard, requirement, criteria, or limitation under Federal environmental law, or any more stringent standard, requirement, criteria, or limitation promulgated pursuant to a State environmental statutes (EPA 1987a). Critical toxicity values and exposure assessments are then integrated to evaluate potential risks to public health and the environment from site-related compounds. Toxicity values and ARARs used in this EA are presented in Section 1.5. The methodology used to perform the quantitative risk assessment is presented in Section 1.6.

Appendix A presents the methodology used to select the chemicals of potential concern. Appendix B discusses the factors that influence the migration potential of the chemicals of potential concern. Appendix C summarizes the assumptions and models used to evaluate exposure. Appendix D presents an overview of the available information on the human health effects and the environmental toxicity of each chemical of potential concern, including critical toxicity values. Appendix E is a compilation of the analytical chemistry data base used in this endangerment assessment to evaluate potential exposure and risk. Appendix F is a species list of the biota found at the Wells G & H site.

1.1 SITE LOCATION AND LAND USE

The Wells G & H site is located in the City of Woburn, Massachusetts approximately 10 miles northwest of Boston (Figure 1-2) and contains five suspected sources of hazardous materials owned by W.R. Grace and Company, New England Plastics, Olympia Nominee Trust, Unifirst Corporation, and Wildwood Conservation Corporation. The site, approximately 450 acres, is bordered by State Route 128 (Interstate Route 95) to the north, Salem St./Cedar St. to the south, Interstate 93 to the east, and the Boston and Main Railroad to the west (Figure 1-3).

The study area encompasses light commercial and light industrial parks which border the wetlands associated with the Aberjona River flood plain. The Aberjona River flows south through the center of the study area. The area to the east, west, and south of the study area is primarily residential. The area to the north of the site is mostly commercial and light industry.

The Wildwood Conservation Corporation (WCC) is an undeveloped 15 acre parcel of land west of Wells G & H as seen in Figure 1-3. The land is bordered by the Boston and Maine railroad to the west, the Aberjona River to the east, Olympia Nominee Trust to the north, and Whitney Barrel Company, Aberjona Autoparts Company, and Murphy Waste Oil Service Company to the south. It appears that disposal of hazardous waste occurred here in the past.

The Cryovac Division of the W.R. Grace and Company facility is located in the northeast portion of the study area (Figure 1-3). This division is involved in the manufacture of food wrapping equipment and has used solvents such as trichloroethene (TCE) as degreasing agents in the past.

Located in the northern section of the study area on Olympia Avenue (Figure 1-3) is the Unifirst Corporation. Unifirst is a uniform cleaning service company that used tetrachloroethene (PCE) in its dry cleaning operations.

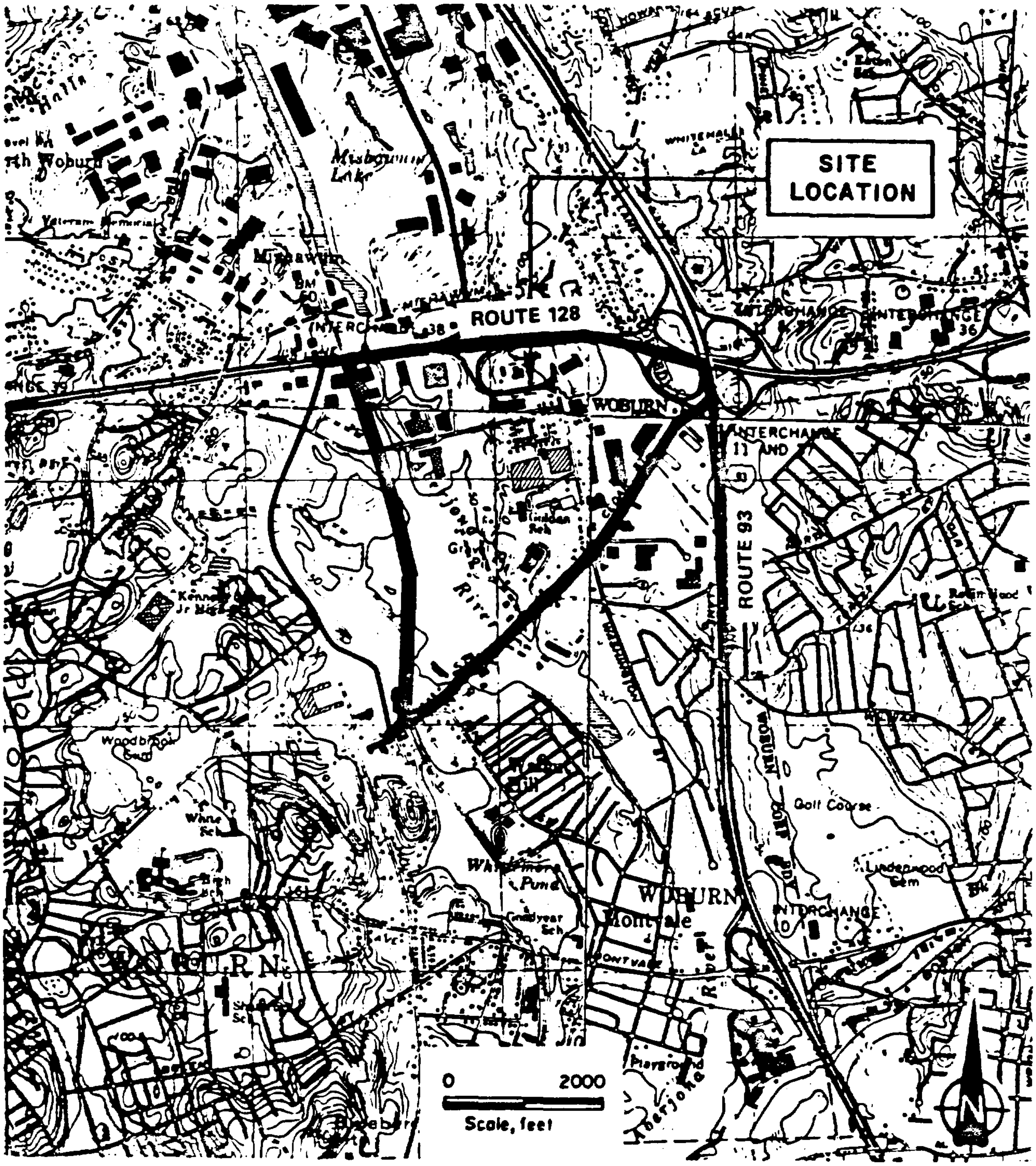
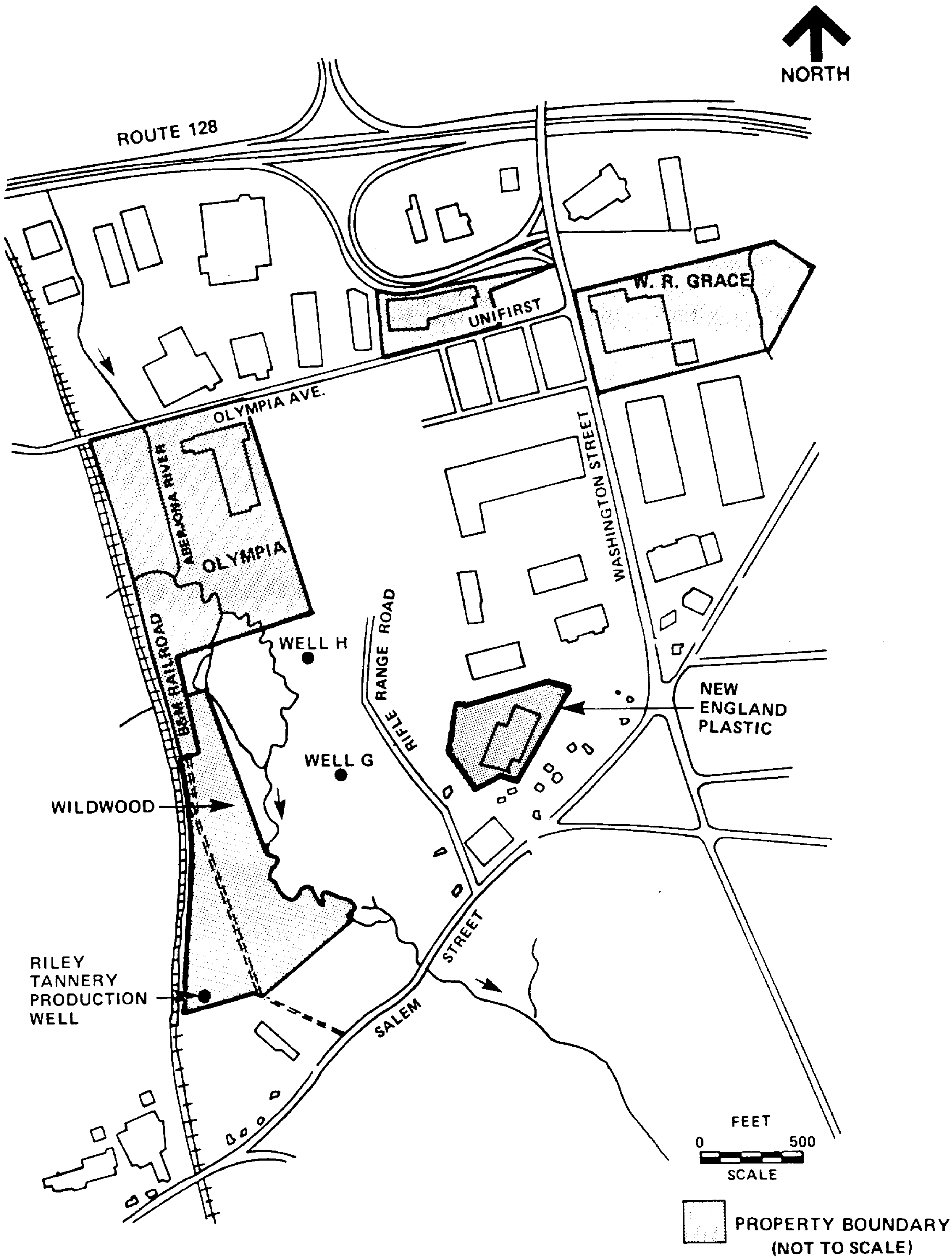


FIGURE 1-2 LOCATION AND APPROXIMATE BOUNDARIES OF THE WELLS G&H SITE. SOURCE: U.S.G.S. 7.5' LEXINGTON, READING, WILMINGTON AND BOSTON NORTH QUADRANGLES.

MAP SOURCE:
ATC WETLANDS ASSESSMENT
WELLS G&H SITE
MARCH,1986

FIGURE 1-3

SITE MAP FOR THE WELLS G & H SITE
WOBURN, MA



The Olympia Nominee Trust Company owns 21 acres of land located in the northeastern section of the site. The property is presently and has been used in the past as a trucking terminal.

The New England Plastics Corporation is located in a building off Salem Street east of Wells G & H, as seen in Figure 1-3. Solid vinyl siding and various other plastic extrusions are manufactured by New England Plastics Corporation. The building is shared with the Prospect Tool and Die Company.

1.2 SITE HISTORY

Wells G & H were drilled by the City of Woburn in 1964 and 1967, respectively. The wells were intended for supplemental use and were capable of supplying 2 million gallons of drinking water per day. In the 1970s an estimated 27 to 28 percent of the community's water supply was provided by Wells G & H (NUS 1986).

On May 4, 1979, 184 55-gallon drums containing polyurethane and toluene were found on a vacant lot located on Mishawum Road (north of Route 128 and the study area). The discovery of the drums prompted the Massachusetts Department of Environmental Quality Engineering (DEQE) to sample Wells G & H, the nearest downgradient water supply, as a precautionary measure. A number of volatile halogenated organics including 1,1,1-trichloroethane (1,1,1-TCA), trans-1,2-dichloroethene (trans-1,2-DCE), PCE, TCE, chloroform, and trichlorotrifluoroethane were detected in the groundwater. As a result, Wells G & H were shut off on May 21, 1979, and the City of Woburn supplemented its public water supply with water from the Metropolitan District Commission (MDC).

In addition to the discovery of contamination of Wells G & H, the Industriplex site was also identified. Industriplex is located to the north of the Wells G & H study area and encompasses a 245-acre industrial park. The major environmental concerns at Industriplex involve heavy metal contamination of soils and sludges, animal glue wastes, and volatile organic contamination of the groundwater (EPA 1982).

In response to contamination at the Wells G & H site and the Industriplex site, the U.S Environmental Protection Agency conducted a hydrogeologic and groundwater quality investigation of a 10-square mile area of East and North Woburn. As a result of the investigation, EPA determined that the major sources of the volatile organics detected at the Wells G & H site were within a 1-square mile area surrounding the wells and not linked with contamination at the Industriplex site. The Wells G & H site was placed on the National Priorities List (NPL) in December 1982.

EPA initiated a Remedial Investigation of the Wells G & H site in 1984. The purpose of the study was to determine the nature and extent of groundwater contamination at the Wells G & H site and to collect data necessary to support a Feasibility Study (FS) (NUS 1986). Alliance Technologies Corporation addressed the soil contamination based on data collected by private parties in a separate volume of the RI report (Alliance 1986).

Recently, EPA performed a supplemental RI which included a field sampling program for soil and groundwater (Ebasco 1988a). The soil sampling was designed to further define the extent of soil contamination at W.R. Grace, New England Plastics, Wildwood Conservation, and Olympia Nominee Trust Properties. The New England Plastics property and Olympia Nominee Trust Property were added to the original list of potential source areas and were sampled to define the nature and extent of contamination suspected there. The groundwater sampling program involved updating information at some of the 150 wells in the study area. An FS is currently being performed to address the contamination found in the study (Ebasco 1988a).

1.3 METHODOLOGY FOR THE SELECTION OF CHEMICALS OF POTENTIAL CONCERN

This section will present the basis for the selection of chemicals of potential concern. During the site investigations conducted by EPA (NUS 1986, Alliance 1986, Ebasco 1988), the soil, groundwater, surface water, and sediments at the Wells G & H site were found to be contaminated by a large number of organic and inorganic compounds. In order to focus this endangerment assessment, the chemicals associated with the greatest potential risk were selected for further evaluation at the Wells G & H site. A complete description of the process and methodology is presented in Appendix A of this document.

The selection of chemicals of potential concern used the validated analytical data collected during the various site investigations and the methodology presented in the Superfund Public Health Evaluation (PHE) manual (EPA 1986a). The selection process was performed on an environmental medium-specific basis for each source area to ensure that the threat to public health, welfare, and the environment would be evaluated with respect to compounds associated only with each individual source area at the site. The criteria that may be considered in selecting chemicals of potential concern include the presence of the chemical in background samples (taken in areas not known to be contaminated) and in blanks, the extent and magnitude of chemical contamination, chemical and physical properties affecting fate and transport of the chemical in the environment, and chemical toxicity.

All chemicals detected in each medium sampled were evaluated in the selection process. Chemicals of potential concern initially were screened based on a comparison to blanks and to background concentrations. Following this initial screening process, chemicals were considered for further evaluation based on their frequency of detection and toxicity.

Chemicals detected in samples at similar concentrations to those detected in laboratory, field, or trip blanks associated with the sample were not selected for detailed evaluation since these included chemicals that may have been introduced during field or laboratory activities. Chemicals detected in samples at significantly higher levels than in blanks were, however, selected for further consideration in the selection process after careful review of the site-relatedness of the reported chemical concentrations.

Concentrations of inorganic chemicals can be compared to regional background concentrations to determine if they may be present at naturally occurring concentrations, or if they have been elevated due to site activities.

Appropriate background samples would be located in areas where site-related chemicals are not expected to occur, that is off-site and sufficiently upgradient or distant to ensure that site-related contamination will not be present but in similar terrain. The Wells G & H site is located in a semi-industrialized area for which is impossible to obtain background concentrations which have not been impacted by human activities. As a result, regional background soil and groundwater concentrations were obtained from the literature to use as a basis for comparison (Shacklette and Boerngen 1984, Connor and Shacklette 1975, Walton 1985, EPA 1985c). The maximum concentration was compared with twice the maximum background concentration to account for natural variations due to mineral enrichment which would be reflected in elevated soil and groundwater concentration. Because there are very few naturally occurring organic chemicals a comparison to background will not be grounds for elimination of those chemicals from further consideration.

After the above initial screening, the frequency of detection of chemicals remaining was evaluated, i.e., if the chemical was detected in approximately 5% or less of the samples in only one or possibly two environmental media. The chemicals screened out based on frequency were further evaluated to ensure that their limited frequency was not due to their presence at potential hot spots or that their detected concentrations were below levels of health concern based on their toxicity.

Chemicals, for which U.S. EPA has not established toxicity criteria for human health and for which available information indicates low toxicity, were eliminated from further consideration in the endangerment assessment. Chemicals for which U.S. EPA has not established human health toxicity criteria but which may not have low toxicity to humans were addressed in a discussion of uncertainty, but were, however, eliminated from quantitative evaluation in the assessment. The environmental effects of these chemicals were also considered before they were eliminated from evaluation in the ecological risk assessment.

Several of the inorganic chemicals detected in the samples are considered to be essential nutrients for humans. Calcium, magnesium, and potassium are essential nutrients in the human diet (recommended daily allowances for adults are 800, 300-500, and 1875-5600 mg/day, respectively) and, in general, more attention has been given to problems of deficiency rather than toxicity. These minerals are typically obtained through food and drinking water (and sometimes mineral supplements), and the body generally has adequate physiological mechanisms to maintain a proper equilibrium over a wide range of intake levels. For this reason, these three elements are not selected as chemicals of potential concern.

Cobalt, copper, iron, manganese, selenium, and zinc are essential metal nutrients with potential for toxicity. Each of these metals has three levels of biologic activity, trace levels required for optimum growth, storage levels, and toxic levels. For these metals, environmental accumulations are generally less important routes of excess exposure than accidents or occupational exposures (Klaassen et al. 1986). Therefore, in the selection process, these chemicals are selected as chemicals of potential concern only if concentrations are greatly elevated (i.e., at least 10 times) above background concentrations.

The analytical chemistry data are summarized using the representative concentration and the maximum detected concentration. The representative concentration of each chemical at the Wells G & H site is considered to be the geometric mean of the positive detections and in samples with non-detects, one-half the U.S. EPA contract laboratory program (CLP) detection limit or, when available, the sample detection limit. In the cases where the detection limit for a specific chemical is unusually high, use of half of this high detection limit would bias the mean, particularly when several samples have high detection limits. Hence, samples in which half of the detection limit exceeds the largest measured concentration of that chemical in that medium will not be used in calculating the mean. The geometric mean was used rather than the arithmetic mean because environmental data generally are log-normally distributed (Dean 1981, Ott 1988). Analytical chemistry samples with a "J" data qualifier, indicating that the chemical was detected but that the reported levels were estimated, were included in the geometric mean calculations. Although the use of these results adds an additional degree of uncertainty to the concentration levels (i.e., may overestimate or underestimate actual values), they have been taken at face value in this assessment. However, if one of these values is seen to play an important role in determining risk, the uncertainty will be noted at that time. If a duplicate sample was collected and analyzed, reported concentrations are first averaged and the average of the two samples is used in calculating geometric means.

1.4 EXPOSURE ASSESSMENT METHODOLOGY

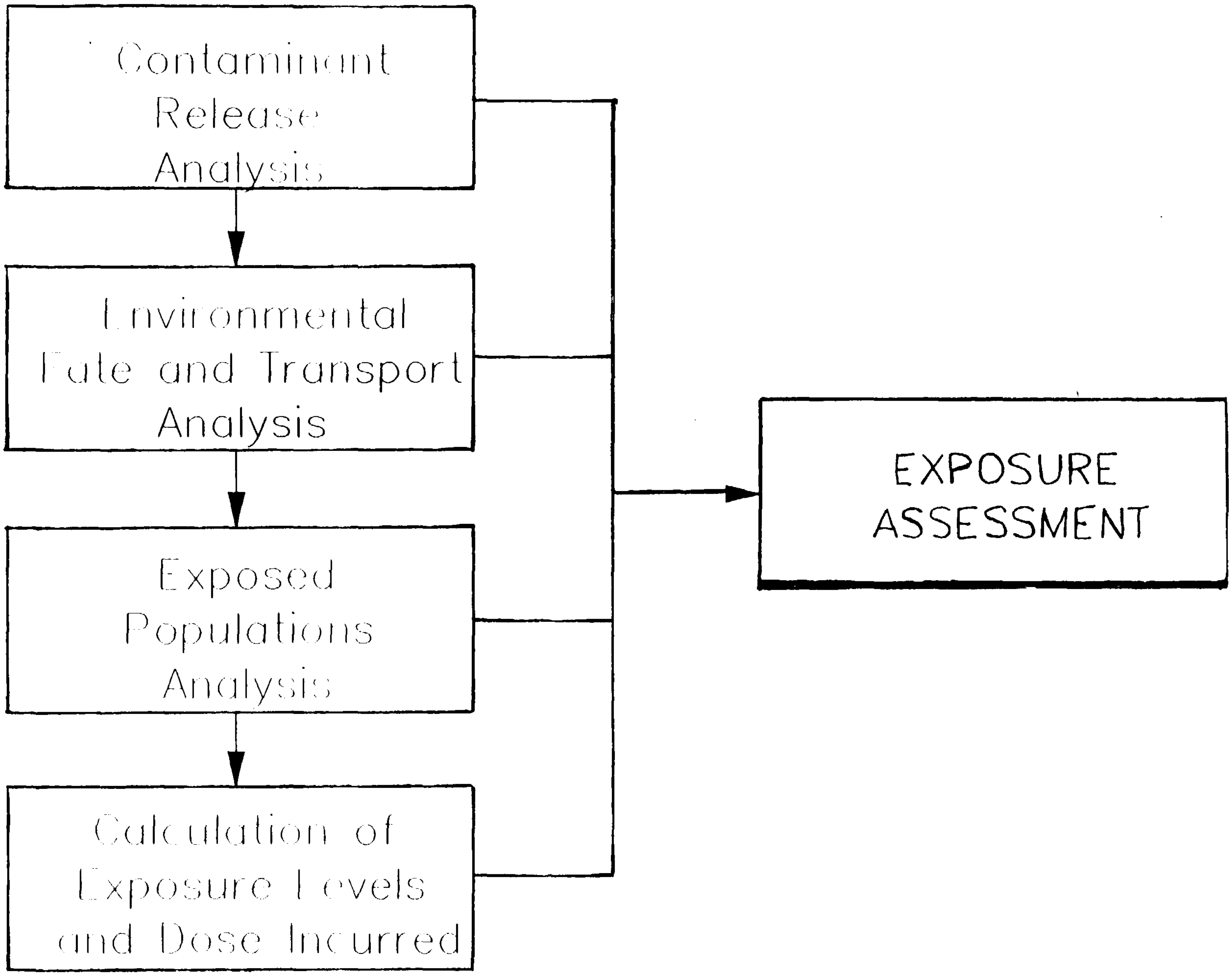
This section will provide an introduction to the elements that will be used later in the text to evaluate exposure to potential receptors to site related contaminants.

The first step in the exposure analysis is to identify complete exposure pathways. An exposure pathway is complete if four elements are present: (1) a source and mechanism of chemical release to the environment, (2) an environmental transport medium (e.g., groundwater, surface water), (3) a point of potential contact with the contaminated medium (the exposure point), and (4) an exposure route at the contact point (e.g., ingestion of groundwater). The purpose of the exposure assessment is to identify current and future human and environmental populations potentially exposed to site contaminants both on and off the site, and the pathways through which they would be potentially exposed. Figure 1-4 illustrates the exposure assessment process.

In order to provide a framework for this information, current and future land uses are identified. Populations associated with exposure within the entire study area are discussed on a property-specific basis, since the nature of the contamination and the exposure pathways differ for each property. It should be noted there will be overlapping pathways and chemicals, for example, under the future-use scenarios, ingestion of groundwater contaminated with tetrachloroethene could occur at several properties. Exposure point concentration estimates are then developed for exposures considered to be potentially significant and for which risk estimates will be made later in the

Fig. 1-4

The Exposure Assessment Process



assessment. Two cases are considered for each exposure scenario. The "average case" will use the representative concentration and average assumptions. The "plausible maximum case" will use the maximum concentration detected and upper bound exposure assumptions. Table 1-1 summarizes the potential exposure pathways which could occur at the Wells G & H site. Each will be evaluated on a property-by-property basis in subsequent chapters of this endangerment assessment to determine applicability. As can be seen in this table, exposure can occur through all media, although the probability of the exposure occurring varies both by medium and by property.

1.5 RISK EVALUATION METHODOLOGY

This section summarizes the methodology that will be used to evaluate risk from exposure to the chemicals of potential concern for each property or area characterized at the Wells G & H site. A more detailed discussion of the toxicological information on the chemicals of potential concern can be found in Appendix D. The general methodology for the classification of health effects and the development of health effects criteria is described in Section 1.5.1 and provides the analytical framework for the characterization of human health impacts in subsequent sections of this report. In Section 1.5.2, the concept of chemical-specific applicable or relevant and appropriate requirements (ARARs) is introduced, and the types of standards, criteria, or guidance that may be classified as potential ARARs for the Wells G & H site are described and the values are presented. Finally, the risk assessment methodology, Section 1.5.3, summarizes the tools that are used to quantitatively evaluate risk.

1.5.1 HUMAN HEALTH EFFECTS CLASSIFICATION AND CRITERIA DEVELOPMENT

For risk assessment purposes, individual pollutants are evaluated by separating them into two categories of chemical toxicity depending on whether or not they exhibit carcinogenic effects. This distinction relates to the currently-held scientific opinion that the biological mechanism of action for each category is different. For the purpose of assessing risks associated with potential carcinogens, EPA has adopted the scientific position that a

TABLE 1-1

POTENTIAL PATHWAYS OF EXPOSURE TO CONTAMINANTS ORIGINATING AT THE WELLS G&H SITE

Exposure Medium	Potential Routes of Exposure	Potential Receptors	Potential for Significant Exposure
Soil	Dermal contact, incidental ingestion	Industrial workers	Low. Soils are contaminated, but some of the properties in the study are are paved.
		Children, young adults	Low to medium. There are residences near the study area; children or young adults could come on the study area. Some of the areas with bare soils are currently fenced, the other areas are primarily paved. In the future, the study area could be redeveloped for residential use.
	Inhalation of volatile contaminants from soil and/or fugitive dust	Individuals in the area	Low to medium. Exposure will be high when pathway operational. Surface soils contain volatile organics. Soil also contains compounds known to adsorb strongly to soil. Probability of exposure decreases because a number of the source areas are paved and vegetated.
		Wildlife	Medium. Wildlife inhabit the area and have access to the site.
	Ingestion of contaminated vegetation	Wildlife	Medium. Soils are contaminated. The potential exists for uptake of contaminants by plants.
Groundwater	Ingestion, inhalation, dermal contact	Residences or industries using groundwater for drinking water and other purposes.	Low. Currently, groundwater for source areas is not used for drinking water. The aquifer in the study area has been used as a drinking water supply and could be used in the future; thus potential for exposure is high in the future. Individuals could choose to develop groundwater wells for private use or production.
Surface water/ sediment	Uptake by wildlife	Aquatic life, wetland community	High. Surface water and sediments contaminated. The potential exists for uptake by biota, wildlife.
	Dermal contact, incidental ingestion	Individuals in the area	Low. Aberjona River and wetlands are not known to be used for recreational purposes within site boundaries.
	Ingestion of contaminated plants	Wildlife	Medium. Surface water and sediments are contaminated. Uptake of the contaminants by vegetation growing in the wetlands can occur.

small number of molecular events can cause changes in a single cell or a small number of cells that can lead to tumor formation. This is described as a no-threshold mechanism because it is assumed that there is essentially no level of exposure (i.e., a threshold) to a carcinogen that will not result in some finite possibility of causing the disease. In the case of chemicals exhibiting noncarcinogenic effects, however, it is believed that organisms have protective mechanisms that must be overcome before the toxic endpoint is manifested. For example, if a large number of cells perform the same or similar functions, it would be necessary for significant damage or depletion of these cells to occur before an effect could be seen. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without appreciable risk of causing the disease (EPA 1987a).

1.5.1.1 Human Health Effects Criteria for Potential Carcinogens

Cancer potency factors, developed by EPA's Carcinogen Assessment Group (CAG) for potentially carcinogenic chemicals are derived from the results of human epidemiological studies or chronic animal bioassays. Potency factors are expressed in units of $(mg/kg/day)^{-1}$. The animal studies on which some potency factors are based must usually be conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed at lower doses than those used in the animal studies, the data are adjusted by using mathematical models. The data from animal studies are fitted to the linearized multistage model to obtain a dose-response curve. The low-dose slope of the dose-response curve is subjected to various adjustments, and an interspecies scaling factor is applied to derive the cancer potency factor for humans. Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an individual basis.

Cancer potency factors derived from animal studies using the linearized multistage model typically provide 95% upper-bound estimates of excess lifetime cancer risks. Whereas the actual risks are unlikely to be higher than those estimated risks, they could be considerably lower. Cancer potency factors derived from high-dose human epidemiological studies are also typically intended to provide upper bound of lifetime cancer risks.

EPA assigns weight-of-evidence classifications to potential carcinogens. Under this system, chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A chemicals (human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer. Groups B1 and B2 chemicals (probable human carcinogens) are agents for which there is limited (B1) or inadequate (B2) evidence of carcinogenicity from human studies but for which there is sufficient evidence of carcinogenicity from animal studies. Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals, and Group D chemicals (not classified as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available. Group E chemicals (evidence of non-carcinogenicity in humans) are agents for which there is no evidence in adequate human or animal studies of carcinogenicity.

1.5.1.2 Human Health Effects Criteria for Noncarcinogens

Health criteria for chemicals exhibiting noncarcinogenic effects are generally developed using risk reference doses (RfDs) developed by the EPA RfD Work Group or RfDs obtained from Health Effects Assessments (HEAs) or from the Office of Drinking Water analysis in support of health-based drinking water standards. The RfD, expressed in units of mg/kg/day, is an estimate of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs usually are derived from human studies involving workplace exposures or from animal studies and are adjusted using uncertainty factors. The RfD provides a benchmark to which chemical intakes in other doses (e.g., via exposure to contaminated environmental media) may be compared.

1.5.1.3 Toxicity of the Chemicals of Potential Concern and Health Effects Criteria for Use in Risk Evaluation

Tables 1-2 and 1-3 presents the health effects criteria that will be used to evaluate potential health risks posed by noncarcinogenic and carcinogenic chemicals of potential concern at the Wells G & H site, respectively. The rationale for selecting the chemicals of potential concern are presented in the property or area-specific chapters. Criteria are presented for both inhalation and oral routes of exposure, when available. Some noncarcinogens do not have an RfD developed specifically for inhalation exposures. In these instances, the RfD derived using the oral exposure route will be used to assess inhalation exposures. This is done because for these specific chemicals lacking inhalation RfDs, the systemic toxic effects are the same following either oral or inhalation exposures. They are assumed to be absorbed with equal efficiency through either route. Potential carcinogenic risks are evaluated using the oral potency factor for all routes if an inhalation potency factor is not available. In this situation, it is assumed that the amount of the chemical absorbed and the potency is the same for both inhalation and oral exposure.

The evaluation of risk from exposure to radionuclides in drinking water is evaluated in a slightly different manner. Cancer potency factors have not been developed for these compounds. Rather, EPA (1985) has determined that "from a uniform whole body dose of 4 mrem/year there are approximately eight excess cancers in a cohort of 100,000 people" or an $8x10^{-5}$ potential upperbound excess cancer risk. EPA (1985) has summarized the concentration of various radionuclides in drinking water which correspond to this risk; these concentrations are used to evaluate risk in subsequent sections.

1.5.2 Applicable or Relevant and Appropriate Requirements (ARARs)

The EPA's interim guidance on ARARs (EPA 1987g) defines ARARs as follows:

> Applicable requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that

TABLE 1-2

CRITERIA FOR CHARACTERIZATION OF NONCARCINOGENIC EFFECTS
FOR CHEMICALS OF POTENTIAL CONCERN AT THE WELLS G&H SITE

	RfD (mg/kg/day)			
Compound	Oral	Source	Inhalation	Source
Acetone	1.0E-1	EPA 1987c	3.0	EPA 1986a
Aldrin	3.0E-5	EPA 1988h	--	
Antimony	4.0E-4	EPA 1987c	--	
Barium	5.0E-2	EPA 1987c	1.4E-4	EPA 1986a
Bis(2-ethylhexyl)phthalate	2.0E-2	EPA 1987c	--	
Cadmium	5.0E-4	(a) EPA 1985c	--	
Chlordane	5.0E-5	EPA 1987c	--	
Chloroform	1.0E-2	EPA 1987c	--	
Chromium (hexavalent)	5.0E-3	EPA 1987c	--	
Copper	3.7E-2	EPA 1986a	1.0E-2	EPA 1986a
4,4'-DDT	5.0E-4	EPA 1987c	--	
1,2-Dichlorobenzene	9.0E-2	EPA 1985c	4.29E-02	EPA 1985c
1,1-Dichloroethane	1.2E-1	EPA 1986a	1.38E-1	EPA 1986a
1,1-Dichloroethene	9.0E-3	EPA 1987c	--	
trans-1,2-Dichloroethene	1.0E-2	EPA 1985c	--	
Iron	1.0E+0	(b) NRC 1980	8.6E-3	(c) EPA 1984i
Lead	6.0E-4	EPA 1985c	--	
Manganese	2.2E-1	EPA 1986a	3.0E-4	EPA 1986a
Mercury	1.4E-3	EPA 1988e	--	
Methylene Chloride	6.0E-2	EPA 1987c	--	
Nickel	2.0E-2	EPA 1987c	--	
PAHs (Naphthalene)	4.1E-1	EPA 1988e	--	
Pentachlorophenol	3.0E-2	EPA 1987c	--	
Phenol	4.0E-2	EPA 1987c	2.0E-2	EPA 1986a
Tetrachloroethene	2.0E-2	EPA 1987c	--	
Toluene	3.0E-1	EPA 1987c	1.5	EPA 1986a
1,1,1-Trichloroethane	9.0E-2	EPA 1987c	3.0E-1	EPA 1986a
Xylenes (mixed)	2.0	EPA 1987c	4.0E-1	EPA 1984a
Zinc	2.1E-1	EPA 1986a	1.0E-2	EPA 1984b

-- = Not available.

(a) An interoffice workgroup of EPA is currently evaluating this criterion. A risk assessment summary of this evaluation will be included in EPA's Integrated Risk Information System when the review is completed.

(b) This number is derived from the recommended dietary allowances (RDAs) for iron from the National Research Council of the National Academy of Sciences.

(c) EPA (1984i) derived a chronic acceptable inhalation intake (AIC) of 0.6 mg/day (0.0086 mg/kg/day) for iron based on the American Conference of Governmental Industrial Hygienists (1986) recommended time-weighted average threshold limit value (TWA-TLV) for the most toxic iron compound evaluated (iron pentacarbonyl).

TABLE 1-3

CRITERIA FOR CHARACTERIZATION OF CARCINOGENIC EFFECTS
FOR CHEMICALS OF CONCERN AT THE WELLS G&H SITE

Compound	Cancer Potency Factors (mg/kg/day)-1 Oral	Inhalation	Weight of Evidence
Aldrin	17	17	B2 (s)
Arsenic	1.5 (n)	50 (p)	A (e,p)
Bis(2-ethylhexyl)phthalate	8.4E-3 (l,m)	--	B2 (e,i)
Cadmium	NA	6.1 (a)	B1 (a)
Chlordane	1.3 (a)	1.3 (a)	B2 (a)
Chloroform	8.1E-2 (c,e,i)	8.1E-2 (c,i)	B2 (e,i)
Chromium (hexavalent)	NA	41 (a,d)	A (a)
4,4'-DDT	3.4E-1 (i,r)	--	B2 (i,r)
1,1-Dichloroethane	9.1E-2 (b,g,h)	--	C
1,2-Dichloroethane	9.1E-2 (a)	9.1E-2 (a)	B2 (a)
1,1-Dichloroethene	6E-1 (a)	1.2 (a)	C (a)
Methylene Chloride	7.5E-3 (a)	1.4E-2 (a)	B2 (a)
PAHs (Benzo(a)pyrene)	11.5 (e,f)	6.11	B2
PCBs (Aroclor 1260)	7.7 (j,k)		B2 (e)
Tetrachloroethene	5.1E-2 (e,i)	3.3E-3 (b,i)	B2 (e,i)
Trichloroethene	1.1E-2 (a)	4.6E-3 (b,e,q)	B2 (a)
Vinyl Chloride	2.3 (e,o)	2.95E-1 (b)	A (e)

-- = Not available.
NA = Not applicable by this route.
(a) EPA 1987b
(b) EPA 1987d
(c) EPA 1985b
(d) EPA 1984c
(e) EPA 1986a
(f) EPA 1984d
(g) The oral cancer potency factor for 1,1-dichloroethane is based on structure-activity relationship to 1,2-dichloroethane (EPA 1988a).
(h) EPA 1988b
(i) An interoffice workgroup of EPA is currently evaluating this criterion. A risk assessment summary of this evaluation will be included in EPA's Integrated Risk Information System when the review is completed.
(j) EPA 1988c
(k) EPA 1987d
(l) EPA 1986e
(m) EPA 1987e
(n) EPA 1987g
(o) EPA 1984e
(p) EPA 1984f
(q) EPA 1984g
(r) EPA 1984h
(s) EPA 1988e

specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

"Applicability" implies that the remedial action or the circumstances at the site satisfy all of the jurisdictional prerequisites of a requirement . . . .

Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

The relevance and appropriateness of a requirement can be judged by comparing a number of factors, including the characteristics of the remedial action, the hazardous substances in question, or the physical circumstances of the site, with those addressed in the requirement. It is also helpful to look at the objective and origin of the requirement. For example, while RCRA regulations are not applicable to closing undisturbed hazardous waste in place, the RCRA regulation for closure by capping may be deemed relevant and appropriate.

A requirement that is judged to be relevant and appropriate must be complied with to the same degree as if it were applicable. However, there is more discretion in this determination: it is possible for only part of a requirement to be considered relevant and appropriate, the rest being dismissed if judged not to be relevant and appropriate in a given case.

Non-promulgated advisories or guidance documents issued by Federal or State governments do not have the status of potential ARARs. However, . . . they may be considered in determining the necessary level of cleanup for protection of health or environment.

Those ARARs or advisories or guidance that "set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants" (EPA 1987b)], are used in this risk assessment.

No federal or Commonwealth of Massachusetts chemical-specific ARARs or guidance are available for the chemicals of potential concern in the soil or sediment at the Wells G & H site. Federal and Commonwealth of Massachusetts ARARs are available for the chemicals of potential concern in groundwater and surface water, however, and those that are considered pertinent to the endangerment assessment for the Wells G & H site are presented in Table 1-4 and are discussed below.

According to EPA's interim guidance on ARARs, Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) are generally applicable or relevant and appropriate standards for water that is or may be used for drinking water source. The groundwater at the Wells G & H site is a potential drinking water source and therefore MCLs will be used as ARARs at this site. Maximum Contaminant Level Goals (MCLGs), also established under the SDWA, are additional chemical-specific criteria which may be considered in the evaluation when neither MCLs or state standards exist for a given chemical (EPA 1987g). The MCLs and MCLGs for the chemicals of potential concern in groundwater are listed in Table 1-4.

Water Quality Criteria adjusted for drinking water intake only also can be considered as ARARs for groundwater exposures when other standards do not exist, but because some of these criteria are based on older toxicological studies, caution must be exercised in using them; when based on the most recent information, these adjusted values are usually equal to the MCLGs. The AWQC for potential carcinogens is set at zero based on the assumption that there is no concentration below which there are no toxic effects. Since this level may not be attainable, the concentrations corresponding to a lifetime incremental cancer risk, given in parentheses in Table 1-4, are used (EPA 1980).

Generally, MCLs and MCLGs for toxic chemicals represent the allowable lifetime exposure to the contaminant for a 70-kg adult who is assumed to ingest 2 liters of water per day for a lifetime. MCLGs are non-enforceable goals which are set at levels which would result in no known or anticipated adverse health effects with an adequate margin of safety. MCLs are enforceable standards set as close to MCLGs as possible, but in addition to health factors, MCLs are required by law to reflect the technological and economic feasibility of removing the contaminant from the water supply. The limit set must be feasible given the best available technology and treatment techniques (EPA 1986a).

TABLE 1-4

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER GUIDANCE FOR CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER

(mg/liter)

	ARAR	Other			
Compound/Metal	MCL	MCLG	AWQC Adjusted for Drinking Water Only	Lifetime Health Advisory	Massachusetts Drinking Water Standards
Acetone	--	--	--	--	0.70
Aldrin	--	--	0 (1.2E-6) (c)	--	--
Antimony	--	--	0.146	--	--
Arsenic	0.05	0.05 (b)	0 (2.5E-6) (c)	0.05	0.05
Barium	1.0	1.5 (b)	--	1.5	1.0
Bis(2-ethylhexyl)phthalate	--	--	21	--	21 (i)
Cadmium	0.01	0.005 (b)	1E-2	0.005	0.01
Chlordane	--	0 (b)	--	--	0 (b,i)
Chloroform	0.1 (a)	--	0 (1.9E-4)	--	0.1 (a)
Chromium:	0.05	0.12 (b)	--	0.12	0.05
III	--	--	179	--	--
VI	--	--	0.05	--	--
Copper	1.3 (b)	1.3 (b)	1 (e)	--	--
4,4'-DDT	--	--	0 (1.2E-6) (c)	--	--
1,2-Dichlorobenzene	--	0.62 (b)	470	0.62	0.60
1,1-Dichloroethane	--	--	(f)	--	--
1,2-Dichloroethane	0.005	0	0 (9.5E-5) (c)	--	0.005
1,1-Dichloroethene	0.007	0.007	3.3E-5	0.007	0.007
trans-1,2-Dichloroethene	--	0.07 (b)	(f)	0.07	0.07 (b,i)
Iron	0.3 (d)	--	--	--	--
Lead (m)	50 [0.005 (b)]	20 (b) [0 (b)]	0.05	0.02	0.05
Manganese	0.05 (d)	--	--	--	0.05 (e)
Mercury	0.002	0.003	0.01	0.0011	0.002
Methylene Chloride	--	--	--	--	--
Nickel	--	--	1.5E-2	0.15	--
cPAHs [Benzo(a)pyrene (g)]	--	--	0 (3.1E-6) (c)	--	3.1E-7 (i)
nPAHs [Naphthalene (h)]	--		--	--	3.1E-7 (i)
PCBs	--	0 (b)	--	--	0 (b,i)
Pentachlorophenol	--	0.22 (b)	--	0.22	--
Phenol	--	--	--	--	3.5 (i)
Radionuclides (pCi/liter)					
- Radium 226 and 228	5 (b)	--	--	10	5
- Gross alpha activity (j)	15 (b)	--	--	10	15
- Gross beta activity (k)	50 (b)				4 mrem/year (k)
- Strontium-90	--	--	--	8	8
- Tritium	--	--	--	20,000	20,000
Tetrachloroethene	--	0 (b)	0 (8.8E-4) (c)	0.01 (l)	0.005
Toluene	--	2.0 (b)	15	2.42	2.0
1,1,1-Trichloroethane	0.20	0.20	19	0.2	0.200
Trichloroethene	0.005	0	0 (2.8E-3) (c)	--	0.005
Uranium	--	--	--	--	--
Vinyl Chloride	0.002	0	0 (2.0E-3) (c)	--	0.002
Xylenes (total)	--	0.44 (b)	--	0.4	0.62
Zinc	5.0 (d)	--	5	--	5 (e)

(a) For total trihalomethanes; refers to sum of chloroform, dibromochloromethane, bromodichloromethane, and bromoform.
(b) Proposed.
(c) The AWQC is set at zero; in parentheses is the level associated with lifetime excess cancer risk of 10-6.
(d) Secondary MCLs based on organoleptic considerations.
(e) Based on organoleptic data.
(f) Insufficient data.
(g) Assumed to apply to all carcinogenic PAHs.
(h) Assumed to apply to all noncarcinogenic PAHs.
(i) Shall not exceed health advisories which have been adopted by the Massachusetts Division of Water Pollution Control and/or the EPA. For groundwater, this would equal the Clean Water Act Criteria for human health (drinking water only) or Safe Drinking Water Act Maximum Concentration Limit Goals, whichever is more stringent.
(j) Gross alpha particle activity includes radium-226 but excludes radon and uranium.
(k) For total beta particle activity, Massachusetts standards are set at the average annual concentration which produces an annual dose equivalent to the total body or any internal organ greater than 4 mrem/year.
(l) Lifetime health advisory was based on the assumption that tetrachloroethene was a Group C carcinogen. Currently, EPA classifies tetrachloroethene as Group B2 - Possible Human Carcinogen.
(m) EPA has proposed new drinking water standards for lead; these values are in brackets.

1.6 QUANTITATIVE RISK ASSESSMENT METHODOLOGY

To quantitatively assess the risks to human health associated with the current-use and future-use exposure scenarios considered in this assessment, the concentrations of chemicals in relevant environmental media (exposure point concentrations) are converted to chronic daily intakes (CDIs). CDIs are the amount of a substance taken into the body per unit body weight per unit time, expressed in units of mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA 1986b) and over the exposure period for noncarcinogens (EPA 1986c).

For potential carcinogens, excess lifetime cancer risks are obtained by multiplying the daily CDI of the contaminant under consideration by its cancer potency factor (q*). This is appropriate for cancer risks of 10^{-2} (i.e., the probability of one in one hundred that an exposed individual would contract cancer) or less. When the daily intakes are large, an alternate approach to obtain the excess lifetime cancer risks is used. The one-hit equation, which is consistent with the linear low dose model used for cancer risks under 10^{-2}, is used:

$$RISK = 1 - e^{-(CDI \times q^{*})}$$

EPA has implemented actions under Superfund associated with total cancer risks ranging from 10^{-4} to 10^{-7} (EPA 1986a). A risk level of 10^{-6} representing an upper bound probability of one in 1,000,000 of contracting cancer might result from exposure to the potential carcinogen, is often used as a benchmark by regulatory agencies. It should be noted that, in general, EPA cancer potency factors are upper bound values based on the linearized multistage model. Thus, the actual risks associated with exposure to a potential carcinogen quantitatively evaluated based on animal data are not likely to exceed the risks estimated using these cancer potency factors, but may be lower. EPA cancer potencies based on human data (e.g., arsenic) are point estimates based on a linear absolute risk model. In its Health Assessment Document for Arsenic (EPA 1984f), the Agency notes that "while it is unlikely that the true risks would be higher than these estimates, they could be substantially lower".

Potential risks are presented for noncarcinogens as the ratio of the chronic daily intake exposure to the reference dose (CDI:RfD). The sum of all of the ratios of chemicals under consideration is called the hazard index. The hazard index is useful as a reference point for gauging the potential effects of environmental exposures to complex mixtures. In general, hazard indices that are less than 1 are not likely to be associated with any health risks and are therefore less likely to be of regulatory concern than hazard indices greater than 1. A conclusion should not be categorically drawn, however, that all hazard indices less than 1 are "acceptable." This is a consequence of the perhaps one-order-of-magnitude or greater uncertainty inherent in estimates of the RfD and CDI, in addition to the fact that the uncertainties associated with the individual terms in the hazard index calculation are additive.

In accordance with EPA's guidelines for evaluating the potential toxicity of complex mixtures (EPA 1986d), it was assumed that the toxic effects of the contaminants of concern would be additive. Thus, lifetime excess cancer risks and the CDI:RfD ratios were summed to indicate the potential risks associated with mixtures of potential carcinogens and noncarcinogens, respectively. In the absence of specific information on the toxicity of the mixture to be assessed or on similar mixtures, EPA guidelines generally recommend assuming that the effects of different components on the mixtures are additive when affecting a particular organ or system. Synergistic or antagonistic interactions may be taken into account if there is specific information on particular combinations of chemicals. In this risk assessment, it was assumed that the effects of the contaminants of concern were additive. Thus, the individual cancer risks or CDI:RfD ratios are summed to determine the total upperbound excess cancer risk or hazard index for a particular exposure scenario.

In the subsequent risk assessment sections, the intakes of chemicals of concern by potentially exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions, such as the routes, frequency, and duration of exposure. For each exposure scenario evaluated, two exposure cases--an average case and plausible maximum case--are considered. For the average exposure case, representative concentrations are used together with what are considered to be the most likely (although conservative) exposure conditions. For the plausible maximum case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the plausible maximum case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

2.0 W.R. GRACE PROPERTY

The Cryovac Division of the W.R. Grace and Company, Inc. is located on 12.6 acres of land in the northeastern portion of the study area, east-northeast of Wells G & H. This division is involved in the manufacture of food wrapping equipment and uses solvents such as trichloroethene as degreasing agents. Remedial measures were undertaken from 1983 to 1985 during which the removal of contaminated soil and drums from a pit east of the plant building occurred.

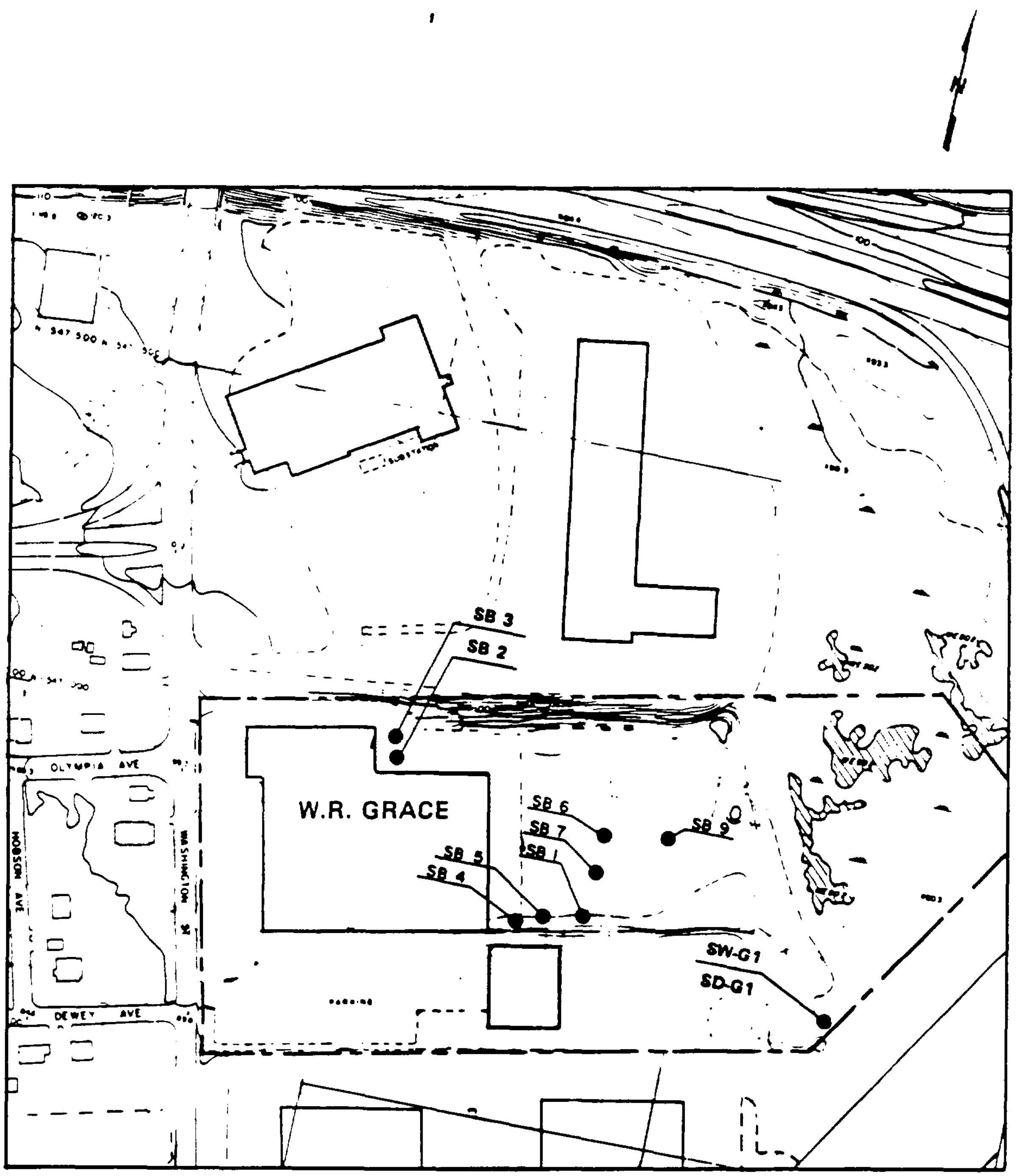
2.1 CHEMICALS OF POTENTIAL CONCERN

The basis for the selection of chemicals of potential concern is outlined in Appendix A of this document. Validated analytical data collected during the various site investigations (NUS 1986, Ebasco 1988a) and the methodology presented in the Superfund Public Health Evaluation manual (EPA 1986a) were used to evaluate the nature and extent of contamination and the potential threat to human health and the environment. Chemicals of potential concern were selected based on the sampling data of environmental media and consideration of toxicity.

2.1.1 SOIL

Soil sampling on the W.R. Grace property conducted in June 1983 and July 1985 revealed the presence of both inorganic and organic compounds. Contaminated soil and drums in and around a former waste disposal area were excavated and removed from the site in 1985. The eight soil samples (collected in the locations marked on Figure 2-1), collected during the supplemental RI (Ebasco 1988a), are used to select chemicals of potential concern since the earlier data do not reflect current conditions at this property. Appendix E contains analytical chemistry data summary tables.

The surface soils at the W.R. Grace property contained detectable levels of three organic chemicals in one of the four samples taken, as seen in Table 2-1. Chloroform and methylene chloride were detected only in the surface



100 0 100 200 300 FEET

SB 1 – SOIL BORING LOCATION AND NUMBER
SW-G1 – SURFACE WATER LOCATION
SD-G1 – SEDIMENT SAMPLE LOCATION
PROPERTY BOUNDARY

U.S. ENVIRONMENTAL PROTECTION AGENCY

WELLS G & H

Figure 2-1
W.R. GRACE PROPERTY
SOIL BORING AND SURFACE WATER SEDIMENT LOCATIONS

TABLE 2-1

COMPOUNDS DETECTED IN SOIL AT W.R. GRACE PROPERTY OF WELLS G & H SITE

COMPOUND	SURFACE SOIL			SUBSURFACE SOIL		
	FREQUENCY OF DETECTION	GEOMETRIC MEAN	MAXIMUM DETECTED VALUE	FREQUENCY OF DETECTION	GEOMETRIC MEAN	MAXIMUM DETECTED VALUE
ORGANICS (ug/kg)						
ACETONE	ND			3/7	8.54	21.00
BENZO(b)FLUORANTHENE	1/1	NA	2.00	ND		
CHLOROFORM	1/4	NA	3.00	ND		
4,4'-DDE	1/1	NA	5.40	ND		
4,4'-DDT	1/1	NA	24.0	ND		
DI-n-BUTYL PHTHALATE	1/1	NA	3.00	1/4	NA	165
METHYLENE CHLORIDE	1/4	NA	3.00	ND		
1,1,1-TRICHLORETHANE	1/4	NA	8.00	4/12	3.43	11.0
INORGANICS (mg/kg)						
ALUMINUM	1/1	NA	13000	1/1	NA	8010
ARSENIC	1/1	NA	15.3	1/1	NA	11.0
BARIUM	1/1	NA	22.0	1/1	NA	24.0
CALCIUM	1/1	NA	857	1/1	NA	1830
CHROMIUM	1/1	NA	23.7	1/1	NA	16.0
COBALT	1/1	NA	5.33	1/1	NA	9.40
COPPER	1/1	NA	16.3	1/1	NA	21.0
IRON	1/1	NA	12400	1/1	NA	13800
LEAD	1/1	NA	37.1	1/1	NA	5.20
MAGNESIUM	1/1	NA	2940	1/1	NA	4730
MANGANESE	1/1	NA	127	1/1	NA	236
MERCURY	1/1	NA	0.06	1/1	NA	0.10
NICKEL	1/1	NA	10.4	1/1	NA	17.0
POTASSIUM	1/1	NA	764	1/1	NA	1300
SODIUM	1/1	NA	81.5	1/1	NA	148
VANADIUM	1/1	NA	24.1	1/1	NA	20.0
ZINC	1/1	NA	40.4	1/1	NA	31.0

ND = Not Detected.
NA = Not applicable; mean not calculated with only one positive detect.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE A GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

soils while 1,1,1-trichloroethane was detected in both surface and soil boring samples. Benzo(b)fluoranthene, 4,4'-DDE, and 4,4'-DDT were not detected in subsurface soils, but were seen in one of the surface soil samples. Di-n-butylphthalate was detected in one surface sample and one of the soil boring samples while acetone was detected in four of eight samples. Acetone was detected at low concentrations and, since it is not very toxic, it will not be selected as a chemical of potential concern. Di-n-butylphthalate was not selected as a chemical of potential concern since it was detected only once in the subsurface soil and at very low levels in one surface sample, and it is not very toxic. 1,1,1-Trichloroethane, the most frequently detected organic, was not selected as a chemical of potential concern due to the very low levels detected (i.e., near the detection limit). The other organic chemicals were not selected as chemicals of potential concern due to their low frequency of detection and low concentrations detected (i.e., near the analytical detection limit).

The sampling results for the inorganic constituents are also summarized in Table 2-1. The criteria for evaluating the inorganic chemicals of potential concern are presented in Appendix A. Inorganic constituents were first compared with regional background levels to determine whether or not they are present at this property due to natural or human related sources. All of the inorganic constituents in surface and subsurface soils were detected at or below typical background levels (Table A-1, Appendix A), and are therefore not considered to be chemicals of potential concern.

Based on the above, there are no soil chemicals of potential concern for the W.R. Grace property.

2.1.2 GROUNDWATER

Groundwater sampling performed during the 1985 and 1987 site investigations (NUS 1985, Ebasco 1988a) are used to select chemicals of potential concern. Data were available from forty-eight samples for volatile organic compounds and eight samples for the semivolatile organic chemicals. Only 1985 filtered data for the inorganic constituents were used in this evaluation because filtered groundwater samples for metals are a more accurate measure of drinking water quality.

Trichloroethene (TCE), the most frequently detected chemical in the groundwater at this site, was detected in 33 of 42 samples. Other frequently detected organic compounds were trans-1,2-dichloroethene, tetrachloroethene, and vinyl chloride, as seen in Table 2-2. 1,2-Dichloroethane and 1,1-dichloroethene were also detected in groundwater at W.R. Grace but not frequently (6 of 46 and 5 of 45 samples, respectively). These six chemicals will be selected as chemicals of potential concern. Ethylbenzene, methylene chloride, toluene, vinyl acetate, and total xylenes were detected in less than 5% of the samples and were not considered to be chemicals of potential concern based upon their frequency of detection. Bis(2-ethylhexyl)phthalate was the only semivolatile organic compound detected at the W.R. Grace site more than once or with a frequency greater than 5%; hence it will be selected as a chemical of potential concern. Naphthalene was detected once at a concentration near the detection limit and in only one sample; as a result, it was not selected as a chemical of potential concern.

A number of inorganic constituents were detected in groundwater as seen in Table 2-2. A comparison to background levels (Table A-2, Appendix A) reveals that the maximum manganese concentration is higher than typical levels. Manganese is, however, an essential nutrient and hence, as discussed in Appendix A, 10 times background is used to evaluate essential nutrient selection as chemicals of potential concern. Since the maximum manganese concentration is less 10 times background and the geometric mean concentration is below background, it is not selected as a chemical of potential concern. It should be noted that although sodium was detected at levels within the background range and not selected as a chemical of potential concern, the geometric mean and maximum concentrations exceeded the Massachusetts advisory level of 20,000 ug/liter for persons on low salt diets.

TABLE 2-2

COMPOUNDS DETECTED IN GROUNDWATER AT THE
W.R. GRACE PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQUENCY OF DETECTION	GEOMETRIC MEAN	MAXIMUM DETECTED VALUE
ORGANICS (ug/liter)			
BIS(2-ETHYLHEXYL) PHTHALATE	5/8	20.5	230
1,2-DICHLOROETHANE	6/46	9.14	800
1,1-DICHLOROETHENE	5/48	5.17	300
TRANS-1,2-DICHLOROETHENE	26/46	57.4	7500
ETHYLBENZENE	2/48	6.15	350
METHYLENE CHLORIDE	1/36	NA	1250
NAPHTHALENE	1/8	NA	5.00
TETRACHLOROETHENE	16/48	6.30	1100
TOLUENE	2/48	6.82	3600
TRICHLOROETHENE	33/42	89.6	2800
VINYL ACETATE	1/48	NA	2500
VINYL CHLORIDE	15/47	24.1	3600
TOTAL XYLENES	2/48	6.34	630
INORGANICS (ug/liter)			
ALUMINUM	1/4	NA	41.0
BARIUM	2/6	11.7	18.0
CALCIUM	6/6	62000	86000
IRON	2/5	63.2	94.0
MAGNESIUM	6/6	16000	41000
MANGANESE	4/6	35.6	540
MERCURY	1/6	NA	0.23
NICKEL	3/5	60.4	140
POTASSIUM	6/6	4000	10000
SODIUM	6/6	27000	43000
ZINC	3/4	24.0	49.0

NA = Not applicable; mean not calculated with only one positive detection.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

2.1.3 SURFACE WATER AND SEDIMENTS

One surface water and one sediment sample were taken from the drainage ditch behind the W.R. Grace property. As seen in Table 2-3, four organic chemicals were detected in sediments at estimated values, and only methylene chloride was detected in surface water. Due to the very low concentrations and the limited sampling, none of these compounds will be selected as chemicals of potential concern. The sediments were analyzed for inorganics and all concentrations were less than the regional soil background. As a result, no inorganic constituents were selected as chemicals of potential concern for the sediments at this property.

2.1.4 SUMMARY

Table 2-4 summarizes the list of chemicals selected to be evaluated further at the W.R. Grace property. No chemicals of potential concern are selected for soil, surface water, or sediment. Chemicals of potential concern for the groundwater are bis(2-ethylhexyl)phthalate, 1,2-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride.

2.2 EXPOSURE ASSESSMENT

2.2.1 PROPERTY UNDER CURRENT-USE CONDITIONS

Under current-use conditions, complete exposure pathways; that is a pathway that has a source of contamination, a route of exposure, and an individual who could be exposed, do not currently exist for any environmental media (i.e., soil, groundwater, surface water, or sediment). The concentrations of chemicals detected in the soil were either very low or at background levels for the inorganic constituents and hence no chemicals of potential concern were selected in Section 2.1.1. Therefore this exposure pathway is incomplete and cannot be evaluated. Soil exposure under current conditions will not be evaluated. Groundwater is not currently used for drinking water purposes;

TABLE 2-3

W.R. GRACE PROPERTY
SURFACE WATER AND SEDIMENT SAMPLE RESULTS

	Sampling Location	
	G-SW EBASCO DATA 1987	G-SD EBASCO DATA 1987
ORGANICS (ug/L)		
VOLATILES		
CHLOROFORM	ND	3
METHYLENE CHLORIDE	1	2
SEMI-VOLATILES		
BENZO(B)FLUORANTHENE	ND	3
CHRYSENE	ND	2
INORGANICS (mg/Kg)		
ALUMINUM	ND	6,170
ANTIMONY	ND	24
ARSENIC	ND	6.3
BARIUM	ND	25
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	ND	2,120
CHROMIUM	ND	11
COBALT	ND	ND
COPPER	ND	8.5
IRON	ND	8,990
LEAD	ND	32
MAGNESIUM	ND	2,850
MANGANESE	ND	79
MERCURY	ND	0.2
NICKEL	ND	4.9
POTASSIUM	ND	434
SELENIUM	ND	ND
SILVER	ND	ND
SODIUM	ND	258
THALLIUM	ND	ND
VANADIUM	ND	19
ZINC	ND	32
CYANIDE	ND	ND

SW = Surface Water
SD = Sediments
ND = Not Detected

TABLE 2-4

CHEMICALS OF POTENTIAL CONCERN FOR THE W.R. GRACE PROPERTY

GROUNDWATER
Bis(2-ethylhexyl)phthalate
1,2-Dichloroethane
1,1-Dichloroethene
trans-1,2-Dichloroethene
Tetrachloroethene
Trichloroethene
Vinyl chloride

thus, this pathway is not complete under current conditions and will not be evaluated here.

2.2.2 PROPERTY UNDER FUTURE-USE CONDITIONS

In the absence of institutional controls limiting future uses of the W.R. Grace property, there are exposure pathways that must be evaluated. It is possible that in the future, the existing facility will be expanded or the property will be redeveloped. Future land use involving excavations for utilities or construction would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short term and due to the negligible concentrations of contaminants in the soil at the W.R. Grace property, it will not be quantified.

This property could be developed for residential purposes in the future, and it is possible that a well to be used to supply drinking water will be installed at the W.R. Grace property. Thus, one exposure scenario would involve the ingestion of groundwater. The concentrations of the chemicals of potential concern in the groundwater at the W.R. Grace property are presented in Table 2-5. Should this water be used in a residential setting, exposure to chemicals in the water could also occur via inhalation and dermal contact from bathing or showering, washing clothes, cooking, washing dishes, and any other household activities which involve the use of water. In this endangerment assessment, exposure via ingestion and inhalation and dermal contact while showering will be evaluated.

The groundwater concentrations of the chemicals of potential concern, summarized in Table 2-5, were used to estimate the air concentrations that might be expected to occur while showering. Using a theoretical exposure model, outlined in Section C.2, Appendix C (Foster and Chrostowski 1986, 1987), the transfer of volatile organic compounds from shower droplets into the air and their subsequent inhalation were estimated. Based on this exposure model, the potential inhalation exposures to the groundwater contaminants which could volatilize were quantified. The model does not

TABLE 2-5

CHEMICALS OF POTENTIAL CONCERN IN THE GROUNDWATER AT W.R. GRACE PROPERTY

COMPOUND	CONCENTRATION (ug/liter)	
	GEOMETRIC MEAN	MAXIMUM
Bis(2-ethylhexyl)phthalate	20.5	230
1,2-Dichloroethane	9.1	800
1,1-Dichloroethene	5.2	300
trans-1,2-Dichloroethene	57.4	7500
Tetrachloroethene	6.3	1100
Trichloroethene	89.6	2800
Vinyl chloride	24.1	3600

estimate dermal absorption of contaminants while showering. However, given the exposure scenario and the physical and chemical properties of the organic compounds considered in this assessment, dermal absorption is likely to result in minimal exposure as compared to exposure via inhalation. The model estimates the intake level (in mg/kg/day), rather than the ambient air concentrations that might be expected while showering. These values are presented in Table 2-6 for the geometric mean and maximum concentrations of the contaminants in groundwater.

2.3 RISK ASSESSMENT

According to guidelines for preparing risk assessments as part of the RI/FS process (EPA 1986a), the potential adverse effects on human health should first be assessed where possible by comparing chemical concentrations found in environmental media at or near the site with applicable or relevant and appropriate requirements (ARARs) or other guidance that has been developed for the protection of human health or the environment. If ARARs are not available for all chemicals and exposures considered, quantitative risk estimates must be developed in addition to the comparison to ARARs. This section will first present a comparison of exposure point concentrations to the applicable or relevant and appropriate requirements (ARARs) and then a quantitative risk assessment.

2.3.1 COMPARISON TO APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER GUIDANCE

In this section, the concentrations of chemicals of potential concern in groundwater at the W.R. Grace property are compared to ARARs or other guidance. Table 2-7 presents this comparison, and as can be seen from the table, some of the ARARs or other guidance are exceeded. The concentrations of 1,2-dichloroethane, trichloroethene, and vinyl chloride exceed their respective MCLs for both the geometric mean and maximum concentrations. Only the maximum concentration of 1,1-dichloroethene exceeds its MCL.

TABLE 2-6

INTAKE OF CHEMICALS OF POTENTIAL CONCERN RELEASED TO THE AIR WHILE SHOWERING WITHGROUNDWATER FROM THE W.R. GRACE PROPERTY

COMPOUND	INTAKE (mg/kg/day) GEOMETRIC MEAN	MAXIMUM
Bis(2-ethylhexyl)phthalate	6.86×10^{-7}	7.70×10^{-6}
1,2-Dichloroethane	2.23×10^{-4}	1.96×10^{-2}
1,1-Dichloroethene	1.49×10^{-4}	8.62×10^{-3}
trans-1,2-Dichloroethene	1.61×10^{-3}	2.10×10^{-1}
Tetrachloroethene	1.47×10^{-4}	2.56×10^{-2}
Trichloroethene	2.25×10^{-3}	7.04×10^{-2}
Vinyl chloride	8.08×10^{-4}	1.21×10^{-1}

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 2-7

COMPARISON OF CHEMICALS OF POTENTIAL CONCERN IN THE GROUNDWATER AT THE W.R. GRACE PROPERTY WITH ARARS AND OTHER GUIDANCE LEVELS

(mg/liter)

Compound	Concentration: Geometric Mean	Concentration: Maximum	ARAR MCL	Massachusetts Drinking Water Standards
Bis(2-ethylhexyl)phthalate	0.0205	0.230	--	21 (b)
1,2-Dichloroethane	0.0091	0.800	0.005	--
1,1-Dichloroethene	0.0052	0.300	0.007	0.007
trans-1,2-Dichloroethene	0.0574	7.500	--	0.07 (a,b)
Tetrachloroethene	0.0063	1.100	--	0.005
Trichloroethene	0.0896	2.800	0.005	0.005
Vinyl Chloride	0.0241	3.600	0.002	0.002

(a) Proposed.

(b) Shall not exceed health advisories which have been adopted by the Massachusetts Division of Water Pollution Control and/or the EPA. For groundwater, this would equate to the Clean Water Act criteria for human health (drinking water only) or the Safe Drinking Water Act Maximum Concentration Limit Goals, whichever is more stringent.

Three of the chemicals of potential concern do not have federal MCLs, thus their concentrations will be compared to other criteria. There is a proposed Massachusetts standard of 0.007 mg/liter for trans-1,2-dichloroethene and this concentration is exceeded by the maximum concentration. There is also a Massachusetts drinking water standard for tetrachloroethene. This concentration is exceeded by both the geometric mean and maximum concentrations. The geometric mean and maximum concentrations of bis(2-ethylhexyl)phthalate are below the Massachusetts drinking water standards.

2.3.2 QUANTITATIVE RISK CHARACTERIZATION

To quantitatively assess the risks to human health associated with the future-use exposure scenarios considered in this assessment, the concentrations of chemicals in relevant environmental media (exposure point concentrations) presented in Section 2.2 are converted to chronic daily intakes (CDIs). CDIs are the amount of a substance taken into the body per unit body weight per unit time, expressed in units of mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA 1986b) and over the exposure period for noncarcinogens (EPA 1986c). Section 1.4.4 summarized the methodology that will be used in this section.

In this section of the risk assessment, the intakes of chemicals of potential concern by hypothetically exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions such as frequency and duration of exposure. For each exposure scenario evaluated, two exposure cases--an average case and plausible maximum case--are considered. For the average exposure case, geometric mean concentrations are used together with what are considered to be the most likely (although often conservative) exposure conditions. For the plausible maximum case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the plausible maximum case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

Chronic daily intakes, excess lifetime cancer risks, and CDI:RfD ratios for the site-related chemicals considered in this assessment, as well as the assumptions and procedures used to calculate these values, are discussed below for each scenario evaluated.

As was discussed in Section 2.2, there are no current exposures to the chemicals of potential concern at the W.R. Grace property. In the absence of future remedial actions and institutional actions limiting access to the use of the groundwater if the property were developed for residential purposes or a new production or drinking water well were installed, individuals (either residents or employees) could be exposed to groundwater contaminants by direct ingestion of tap water, or by inhalation of volatilized contaminants while using the water for nonconsumptive uses. It is possible that if the groundwater were used as production water, individuals employed at the plant could be exposed to vapors released during the use of the water. Only potential individual residential exposures will be quantified here, however. This is because residential exposure may occur for longer periods of time than industrial exposure. Also there may be more routes of exposure in the home than in the plant.

2.3.2.1 Ingestion of Groundwater

Under this future-use scenario, the average individual is assumed to weigh 70 kg and drink 2 liters of water each day for 70 years (an average lifetime). Based on these assumptions, and the existing chemical concentrations in the groundwater, chronic daily intakes were derived and are presented in Table 2-8. The risks associated with these intake levels are also presented therein for chemicals potentially exhibiting carcinogenic and noncarcinogenic effects.

The upper bound lifetime excess cancer risks associated with ingestion are 2×10^{-3} (i.e., two in one thousand) and 2×10^{-1} (i.e., two in ten) for the average and plausible maximum cases, respectively. These risks are due primarily to the presence of vinyl chloride in the groundwater. The average and plausible maximum upper bound lifetime excess cancer risks for the other chemicals of potential concern also exceed 1×10^{-6} or one in a million. A

TABLE 2-8

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER AT W.R. GRACE PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	20.5	230	5.86E-04	6.57E-03	8.40E-03	4.9E-06	5.5E-05
1,2-Dichloroethane	9.1	800	2.60E-04	2.29E-02	9.10E-02	2.4E-05	2.1E-03
1,1-Dichloroethene	5.2	300	1.49E-04	8.57E-03	6.00E-01	8.9E-05	5.1E-03
Tetrachloroethene	6.3	1100	1.80E-04	3.14E-02	5.10E-02	9.2E-06	1.6E-03
Trichloroethene	89.6	2800	2.56E-03	8.00E-02	1.10E-02	2.8E-05	8.8E-04
Vinyl chloride	24.1	3600	6.89E-04	1.03E-01	2.30E+00	1.6E-03	2.4E-01
TOTAL	--	--	--	--	--	2E-03	2E-01

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	20.5	230	5.86E-04	6.57E-03	2.00E-02	2.9E-02	3.3E-01
1,1-Dichloroethene	5.2	300	1.49E-04	8.57E-03	9.00E-03	1.7E-02	9.5E-01
trans-1,2-Dichloroethene	57.4	7500	1.64E-03	2.14E-01	1.00E-02	1.6E-01	2.1E+01
Tetrachloroethene	6.3	1100	1.80E-04	3.14E-02	2.00E-02	9.0E-03	1.6E+00
HAZARD INDEX	--	--	--	--	--	<1 (0.2)	>1 (24)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the size of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

CDI:RfD ratio of greater than one was calculated for trans-1,2-dichloroethene and tetrachloroethene using plausible maximum assumptions. This results in a hazard index, under the plausible maximum case for all chemicals exhibiting noncarcinogenic effects, greater than one, suggesting a potential threat to human health. The non-cancer risk associated with ingestion results primarily from exposure to tetrachloroethene and trans-1,2-dichloroethene. The similarities in chemical structure, target organs, and toxicity endpoints between these two chemicals supports the use of the hazard index and as such, their concentrations should be considered additive. The geometric mean concentration of trans-1,2-dichloroethene and the geometric mean and maximum concentrations of tetrachloroethene are both less than the 1 day and 10 day health advisories for children (EPA 1987h,i). The maximum concentration of trans-1,2-dichloroethene exceeds the 10 day health advisory of 1,430 ug/liter for children (EPA 1987h). The cumulative hazard index under the average case is less than one.

2.3.2.2 Inhalation Of Contaminants While Showering

Individuals may become exposed to chemicals of potential concern in groundwater by inhalation of volatilized chemicals while showering. The shower model of Foster and Chrostowski (1987), discussed in Appendix C, Section C.2, quantify exposure via this pathway. The potential health risks associated with the estimated inhalation exposures while showering are presented in Table 2-9. It should be noted that while the chronic daily intake for exposure to volatile organic contaminants in groundwater via ingestion and inhalation are comparable, as expected from the literature (Foster and Chrostowski 1987, McKone 1987, EPA 1984i), the risks from this exposure will vary due to differences in the oral and inhalation potency factors.

The excess upper bound lifetime cancer risks associated with the average and plausible maximum cases were $4x10^{-4}$ (i.e., four in ten thousand) and $5x10^{-2}$ (i.e., five in a hundred), respectively. These were due primarily to the presence of vinyl chloride and 1,1-dichloroethene. For chemicals exhibiting noncarcinogenic effects, the individual CDI:RfD ratios for each compound under average conditions was below one as was the corresponding hazard index. Under

TABLE 2-9

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION WHILE SHOWERING
WITH GROUNDWATER FROM THE W.R. GRACE PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	6.86E-07	7.70E-06	8.40E-03	5.8E-09	6.5E-08
1,2-Dichloroethane	2.23E-04	1.96E-02	9.10E-02	2.0E-05	1.8E-03
1,1-Dichloroethene	1.49E-04	8.62E-03	1.20E+00	1.8E-04	1.0E-02
Tetrachloroethene	1.47E-04	2.56E-02	3.30E-03	4.9E-07	8.4E-05
Trichloroethene	2.25E-03	7.04E-02	4.60E-03	1.0E-05	3.2E-04
Vinyl chloride	8.08E-04	1.21E-01	2.95E-01	2.4E-04	3.6E-02
TOTAL	--	--	--	4E-04	5E-02

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	6.86E-07	7.70E-06	2.00E-02	3.4E-05	3.9E-04
1,1-Dichloroethene	1.49E-04	8.62E-03	9.00E-03	1.7E-02	9.6E-01
trans-1,2-Dichloroethene	1.61E-03	2.10E-01	1.00E-02	1.6E-01	2.1E+01
Tetrachloroethene	1.47E-04	2.56E-02	2.00E-02	7.3E-03	1.3E+00
HAZARD INDEX	--	--	--	<1 (0.2)	>1 (23)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the size of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

the plausible maximum exposure scenario, the hazard index exceeds one due to individual CDI:RfD ratios greater than one for trans-1,2-dichloroethene and tetrachloroethene. Exposure to these two chemicals can be considered additive since one of their toxic end points (liver damage) is the same.

2.4 SUMMARY OF W.R. GRACE PROPERTY EVALUATION

This section of the endangerment assessment for the W.R. Grace property is a baseline assessment, which evaluates potential impacts to human health in the absence of further remedial actions under both current- and future-use scenarios. Chemicals of potential concern were selected based on the sampling data of the environmental media and consideration of toxicity. Those selected for the groundwater were bis(2-ethylhexyl)phthalate, 1,2-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride. No chemicals of potential concern were selected for the soils, surface water, or sediments.

Under current land-use conditions, there are no exposure pathways by which human receptors could potentially be exposed to site contaminants. Under future-use conditions, exposure pathways related to groundwater use were considered. Average and plausible maximum exposure scenarios were developed for ingestion of groundwater and inhalation of volatiles released while showering. The conclusions are summarized as follows:

- If the groundwater at the property was to be developed as a drinking water source, ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of 2×10^{-3} and 2×10^{-1} for the average and plausible maximum cases, respectively. Exposure to noncarcinogenic chemicals of potential concern would result in a hazard index less than 1 for the average case but greater than 1 for the plausible maximum case.
- Inhalation of volatiles released from the groundwater while showering could result in 4×10^{-4} and 5×10^{-2} potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average case but exceeded 1 for the plausible maximum case, for exposure to the noncarcinogen chemicals of potential concern.

3.0 NEW ENGLAND PLASTICS CORPORATION

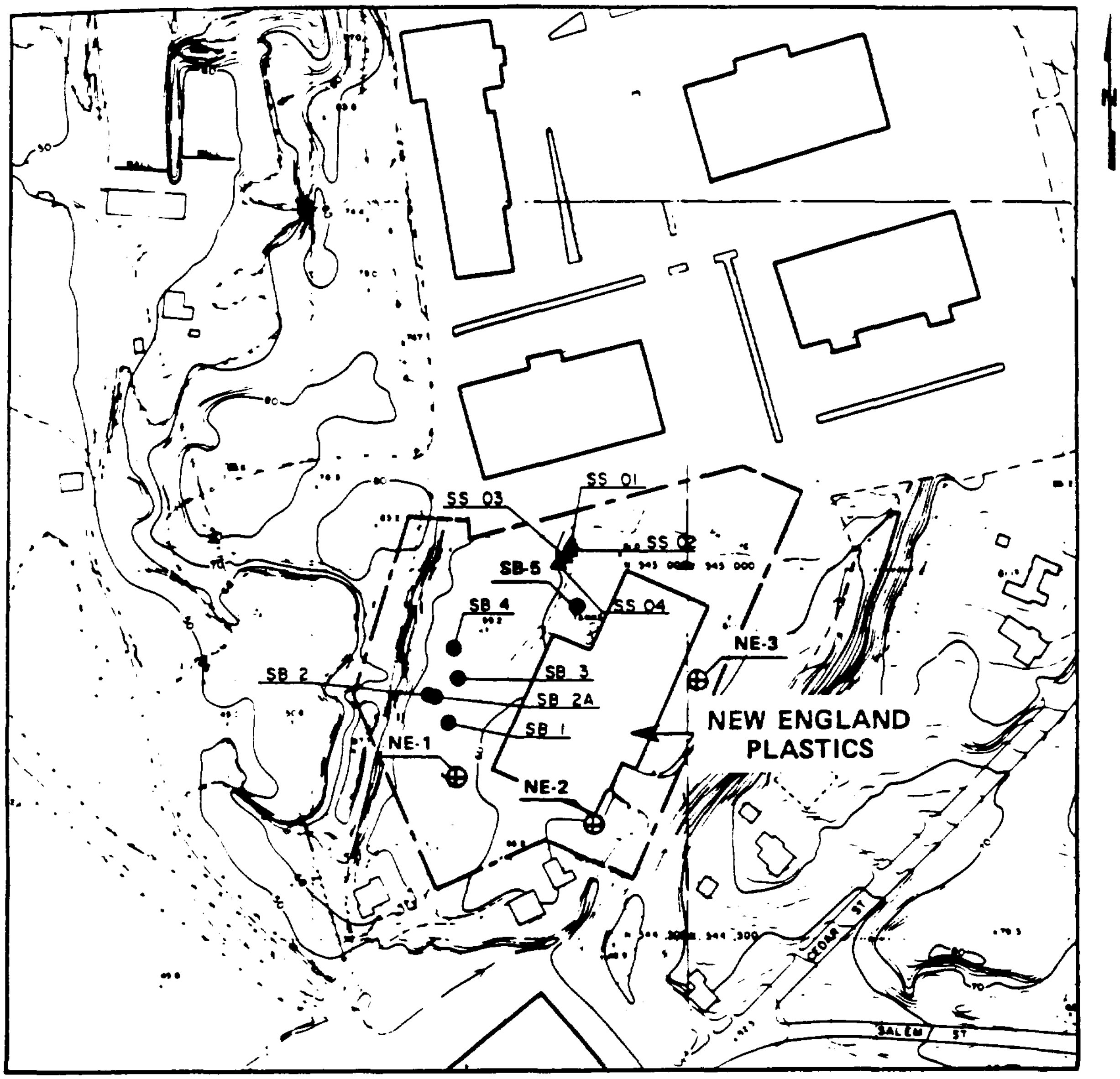
The New England Plastics Corporation manufactures solid vinyl siding and various other extruded plastics. The company is housed in a building off of Salem Street east of Wells G & H (Figure 1-2). The building is shared with the Prospect Tool and Die Company. This property was not investigated during the first remedial investigation (NUS 1986, Alliance 1986) and was added to the list of possible source areas by U.S. EPA based on the detection of groundwater contamination.

3.1 CHEMICALS OF POTENTIAL CONCERN

The basis for the selection of chemicals of potential concern is outlined in Appendix A of this document. Validated analytical data (presented in Appendix E) collected during the Ebasco supplemental remedial investigation and the methodology presented in the Superfund Public Health Evaluation manual (EPA 1986a) were used to evaluate the nature and extent of contamination and to select the chemicals that might pose the greatest threat to human health and the environment.

3.1.1 SOIL

Ebasco sampled four surface soil locations and five soil boring locations behind the New England Plastics Corporation building as seen in Figure 3-1. Most of the contamination was detected in the surface soil samples. The sampling results are summarized in Table 3-1. All of the organic compounds detected more than once in surface and subsurface soils, with the exception of di-n-octyl phthalate, were considered to be chemicals of potential concern due to the high concentrations and frequency of detection in soils. Di-n-octyl phthalate was not selected as a chemical of potential concern due to insufficient toxicity information. Thus, acetone, bis(2-ethylhexyl)phthalate, methylene chloride, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene are selected as chemicals of potential concern for the soils. Acetone, bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, and methylene



100 0 100 200 300 FEET

● SB 1 – SOIL BORING LOCATION AND NUMBER
⊕ NE-1 – WELL BORING LOCATION AND NUMBER
▲ SS 01 – SURFACE SOIL LOCATION AND NUMBER
——— — ——— PROPERTY BOUNDARY

U.S. ENVIRONMENTAL PROTECTION AGENCY

WELLS G & H

Figure 3-1
NEW ENGLAND PLASTICS
SOIL SAMPLING LOCATIONS

EBASCO SERVICES INCORPORATED

TABLE 3-1

COMPOUNDS DETECTED IN SOIL AT NEW ENGLAND PLASTICS CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	SURFACE SOILS			SUBSURFACE SOILS		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/kg)						
VOLATILES						
ACETONE	1/5	NA	120000	3/7	11.6	26.0
BENZENE	1/7	NR	1.00	ND		
CHLOROFORM	1/7	NA	3.00	ND		
METHYLENE CHLORIDE	3/5	50.3	9400	4/8	6.64	19.0
TETRACHLOROETHENE	5/7	360	1200000	ND		
1,1,1-TRICHLORETHANE	4/7	19.4	13000	ND		
TRICHLOROETHENE	4/7	56.6	110000	ND		
SEMI-VOLATILES						
BENZOIC ACID	1/7	NR	290	ND		
BIS(2-ETHYLHEXYL)PHTHALATE	4/7	19000	4400000	9/12	250	7500
CHRYSENE	1/7	NR	120	ND		
DI-N-BUTYL PHTHALATE	1/7	NR	73.0	ND		
DI-N-OCTYL PHTHALATE	2/7	1400	640000	3/12	125	165
PESTICIDES/PCB'S						
AROCLOR-1260	1/7	NA	580	ND		
INORGANICS (mg/kg)						
ALUMINUM	7/7	7900	10100	12/12	7600	10100
ANTIMONY	1/7	NA	7.10	2/12	3.65	12.0
ARSENIC	6/7	3.23	6.80	7/12	1.75	6.70
BARIUM	7/7	58.9	176	12/12	24.9	43.0
BERYLLIUM	5/7	NR	0.20	6/12	0.16	0.30
CADMIUM	5/7	2.32	17.0	5/12	0.68	8.00
CALCIUM	7/7	2200	4680	12/12	2600	5260
CHROMIUM	7/7	13.5	21.0	12/12	13.1	22.0
COBALT	7/7	8.71	31.0	12/12	7.72	13.0
COPPER	7/7	56.3	161	12/12	18.4	36.0
IRON	7/7	11000	18400	12/12	12000	23100
LEAD	7/7	52.6	289	12/12	7.66	17.0
MAGNESIUM	7/7	2800	4860	12/12	3600	6680
MANGANESE	7/7	120	207	12/12	150	312
MERCURY	ND			3/12	0.02	0.16
NICKEL	7/7	12.7	23.0	12/12	10.9	21.0
POTASSIUM	5/5	750	951.0	6/6	1000	1880
SODIUM	2/7	210	250.0	6/12	213	282
VANADIUM	7/7	27.1	40.0	12/12	24.3	40.0
ZINC	7/7	47.8	65.0	12/12	24.8	37.0

NA = Not applicable; mean not calculated with only one positive detection.

ND = Not detected.

NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

chloride were detected in the subsurface soils at this property but at levels much lower than the surface soils.

Most of the inorganic constituents were detected in soils within the background range of concentrations seen in Table A-1 of Appendix A, with the exception of cadmium, copper, lead, and zinc. Copper and zinc were not selected as chemicals of concern because they are essential nutrients and the concentrations fell within the criteria (i.e., ten times background) used to screen out these chemicals. Both the geometric mean and maximum concentrations of cadmium exceeded the background range. Lead was detected at geometric mean and maximum concentrations which exceeded regional Massachusetts soil concentrations (Shacklette and Boerngen 1984). In comparison with Eastern United States soils, the geometric mean concentration of lead fell within the range but the maximum exceeded twice the maximum background level. Therefore, while cadmium and lead are not considered to be property related, they were selected as a chemicals of potential concern for the New England Plastics Corporation property.

3.1.2 GROUNDWATER

Three groundwater monitoring wells were installed at the New England Plastics Corporation property during the supplemental RI as seen in Figure 3-1. Samples were also taken from three existing process wells. The data are summarized in Table 3-2. The most frequently detected organic compounds, <u>trans</u>-1,2-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene, were selected as chemicals of potential concern. The other organics detected in the groundwater were not selected as chemicals of potential concern because of the low levels detected (i.e., at or near the detection limit).

The concentrations of inorganic constituents detected in groundwater were compared with the background concentrations presented in Table A-2 in Appendix A. None of the inorganic compounds were detected at levels above background. Therefore, no inorganics were selected as chemicals of potential concern. It

TABLE 3-2

COMPOUNDS DETECTED IN GROUNDWATER AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/liter)			
BENZENE	1/9	NA	2.50
CHLOROFORM	2/9	2.04	2.50
1,1-DICHLOROETHANE	1/9	NA	2.50
TRANS-1,2-DICHLOROETHENE	6/9	3.22	11.0
TETRACHLOROETHENE	8/9	49.4	330
1,1,1-TRICHLOROETHANE	7/9	6.88	26.0
TRICHLOROETHENE	7/8	19.6	59.0
TOTAL XYLENES	1/9	NA	6.00
INORGANICS (ug/liter)			
BARIUM	2/2	14.5	34.9
CALCIUM	2/2	30400	32100
IRON	1/2	NA	36.8
MAGNESIUM	2/2	5510	5600
MANGANESE	1/2	NA	19.3
POTASSIUM	2/2	2280	2390
SODIUM	2/2	28800	58500
ZINC	2/2	22.5	23.9

NA = Not applicable; mean not calculated with only one positive detection.

should be noted, however, that the geometric mean and maximum sodium concentrations exceeded the Massachusetts advisory level of 20,000 ug/liter for persons on low salt diets.

3.1.3 SUMMARY

The chemicals of potential concern selected for further evaluation at the New England Plastics Corporation property are summarized in Table 3-3. The soil chemicals of potential concern are acetone, bis(2-ethylhexyl)phthalate, cadmium, lead, methylene chloride, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene. The groundwater chemicals of potential concern are trans-1,2-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene.

3.2 EXPOSURE ASSESSMENT

3.2.1 PROPERTY UNDER CURRENT-USE CONDITIONS

Under current-use conditions, groundwater and soil exposures will be considered. Groundwater is not currently used for drinking water purposes although it is used for production purposes. Exposure can occur through the volatilization of organic contaminants from groundwater used in the production process; this pathway will be evaluated here. The contaminated soil at this property could act as a source of volatile organics to the air. However, conditions at the New England Plastics Corporation property do not favor air releases because the contaminated area is very small.

Groundwater is used in the production process at the New England Plastics Corporation. There are seven troughs through which water is flowing constantly at a rate of 1 to 4 gallons per minute (gpm). The largest trough is 10.66 ft^3 and the smallest is 2.85 ft^3. The largest trough is 16 ft. long by 13 inches wide with a surface are of 17.3 ft^2. There are also two recirculation tanks. A surface water volatilization model, outlined in Appendix C, was used to estimate indoor air concentrations. Although there are 9 tanks/troughs of various sizes, the surface area of the largest tank was

TABLE 3-3

CHEMICALS OF POTENTIAL CONCERN FOR THE NEW ENGLAND PLASTICS PROPERTY

SOIL	GROUNDWATER
Acetone	trans-1,2-Dichloroethene
Bis(2-ethylhexyl)phthalate	Tetrachloroethene
Cadmium	1,1,1-Trichloroethane
Lead	Trichloroethene
Methylene chloride	
Tetrachloroethene	
1,1,1-Trichloroethane	
Trichloroethene	

used in the model and then the ambient air concentration assumed to be nine times this value. This may overestimate releases from the tanks, and the results may present an upper bound concentration. Table 3-4 summarizes the results of the model.

Industrial and maintenance workers are currently employed and present at New England Plastics Corporation. The worker population at this business is likely to remain indoors most of the day. There is an open area behind the building and it is assumed that during good weather, individuals could play basketball and eat lunch and be outdoors for one hour each day. Thus, these individuals could be exposed to contaminated soil via dermal absorption from or incidental ingestion of contaminated soil. It is assumed that for the average case scenario, an individual will be outdoors three days a week for four months or 48 days per year for 10 years. For the plausible maximum exposure scenario, an individual would be outside for five days each week for five months or 100 days per year for 20 years of employment. The soil concentrations an individual could be exposed to are summarized in Table 3-5.

In addition to exposure via direct contact with contaminated soils, the worker population may inhale volatile organics released from the soil. Cadmium and lead are not considered in this pathway since they are not volatile chemicals. The volatilization of chemicals from the soil is dependent upon soil conditions and the physicochemical properties of the compound. Highly organic soils retard diffusion and mass transport because the soil particles can act to sorb the organic compounds to them. This is true for compounds with high K_{oc}s such as bis(2-ethylhexyl)phthalate as well as the more volatile compounds such as tetrachloroethene, for example (Urano and Murata 1985). Highly porous and dry soils have a higher diffusion rate because there are more air spaces for the organic compounds to move through. A mathematical model (Karimi 1987) summarized in Appendix C was used to calculate the emission rate due to soil volatilization of organic contaminants in the New England Plastics Corporation property soils. Table 3-6 summarizes the results of the model. Although the area of contaminated soil is not vegetated, the generation of large quantities of fugitive dust is assumed to be improbable since the area is so small.

TABLE 3-4

CONCENTRATION OF CHEMICALS OF POTENTIAL CONCERN IN PROCESS WATER AND INDOOR AIR AT NEW ENGLAND PLASTICS CORPORATION

Compound	Water Concentration (ug/liter)		Air Concentration (mg/m^3)	
	Geometric Mean	Maximum	Average	Maximum
trans-1,2-Dichloroethene	NA	9	--	2.19×10^{-4}
Tetrachloroethene	35.3	270	6.75×10^{-4}	5.16×10^{-3}
1,1,1-Trichloroethane	5.03	17	1.08×10^{-4}	3.64×10^{-4}
Trichloroethene	12.2	52	2.58×10^{-4}	1.10×10^{-3}

NA = Not Applicable; geometric mean not calculated when only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 3-5

CONCENTRATION OF CHEMICALS OF POTENTIAL CONCERN
NEW ENGLAND PLASTICS CORPORATION PROPERTY SOILS

COMPOUND	CONCENTRATION (ug/kg)	
	GEOMETRIC MEAN	MAXIMUM
Acetone	NA	120,000
Bis(2-ethylhexyl)phthalate	19,300	4,400,000
Cadmium	2,320	17,000
Lead	52,600	289,000
Methylene chloride	50.3	9400
Tetrachloroethene	361	1,200,000
1,1,1-Trichloroethane	19.4	13,000
Trichloroethene	56.6	110,000

TABLE 3-6

AIR CONCENTRATIONS RESULTING FROM VOLATILIZATION FROM SOIL
AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

Compound	Air Concentration (mg/m^3)	
	Average	Maximum
Acetone	NA	3.12×10^{-6}
Bis(2-ethylhexyl)phthalate	4.61×10^{-14}	1.07×10^{-11}
Methylene Chloride	1.73×10^{-8}	3.23×10^{-6}
Tetrachloroethene	2.28×10^{-8}	7.62×10^{-5}
1,1,1-Trichloroethane	3.86×10^{-9}	2.59×10^{-6}
Trichloroethene	4.40×10^{-9}	8.55×10^{-6}

NA = Not applicable; mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

3.2.2 PROPERTY UNDER FUTURE-USE CONDITIONS

In the absence of institutional controls limiting access of future uses of the New England Plastics property, there are additional exposure pathways that must be evaluated. It is possible that in the future, the existing facilities will be expanded or redeveloped. Future land use involving excavations for utilities or construction would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short-term compared with the exposure scenario developed for industrial workers under current-use conditions. Therefore, this scenario will not be quantified.

It is also possible that in the future, this property will be developed for residential purposes. Should this occur, the potential exists for residents living on the property to be exposed to contaminated soils during outdoor activities. Exposure is assumed to occur via direct contact with contaminated soils with subsequent ingestion and dermal absorption of chemicals. The exposure point concentration is assumed to be the same as that presented in Table 3-5. This is a conservative assumption because the organic chemicals of potential concern are likely to volatilize over time, thereby reducing their soil concentration. Because these exposures are assumed to occur over a lifetime, time-weighted averages for the amount of soil ingested per exposure event, the dermal soil contact rate, and an individual's body weight were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime.

While an individual resident is outdoors, exposure to volatile organics may occur. This exposure scenario provides a conservative estimate of exposure because it assumes that the concentrations of the chemicals of potential concern in soil remain constant over time. In reality, these concentrations will decrease over time. The individual inhalation rate is averaged over a lifetime, as in the direct contact with soil exposure scenario, to account for age variations. The air concentrations derived under the current-use scenario (Table 3-6) are assumed to apply here. It should be noted that this scenario does not consider inhalation exposure of volatiles which could migrate from outdoors into the home. Thus, in terms of total exposure, this scenario may underestimate exposure and risk.

It is also possible that in the future a well to be used for drinking water purposes will be installed at the New England Plastics property. Thus, another exposure scenario would involve the ingestion of groundwater. Should this water be used in a residential setting, exposures could occur via inhalation and dermal contact from bathing or showering, washing clothes, cooking, washing dishes, and any other household activities which involve the use of water. In this endangerment assessment, exposure via ingestion and dermal contact inhalation while showering will be evaluated. The groundwater concentrations an individual might be exposed to are summarized in Table 3-7.

The groundwater concentrations of the chemicals of potential concern summarized in Table 3-7 were used to estimate the concentrations that might be expected to occur while showering. Using a theoretical exposure model, outlined in Appendix C, Section C.2, (Foster and Chrostowski 1986, 1987), the transfer of volatile organic compounds from shower droplets into the air and their subsequent inhalation were estimated. Based on this exposure model, the potential inhalation exposures to the groundwater contaminants which could volatilize were quantified. The model does not estimate dermal absorption of contaminants while showering. However, given the exposure scenario and the physical and chemical properties of the organic compounds considered in this assessment, dermal absorption is likely to result in minimal exposure as compared to exposure via inhalation. The model estimates the intake level (in mg/day), rather than the ambient air concentrations that might be expected while showering. These values are presented in Table 3-8 for the geometric mean and maximum concentrations of the contaminants in groundwater.

3.3 RISK ASSESSMENT

According to guidelines for preparing risk assessments as part of the RI/FS process (EPA 1986a), the potential adverse effects on human health should

TABLE 3-7

CONCENTRATION OF CHEMICALS OF POTENTIAL CONCERN
NEW ENGLAND PLASTICS CORPORATION PROPERTY GROUNDWATER

COMPOUND	CONCENTRATION (ug/liter) GEOMETRIC MEAN	MAXIMUM
trans-1,2-Dichloroethene	3.2	11.0
Tetrachloroethene	49.4	330
1,1,1-Trichloroethane	6.9	26.0
Trichloroethene	19.6	59.0

TABLE 3-8

INTAKE OF CHEMICALS OF POTENTIAL CONCERN RELEASED TO THE AIR WHILE SHOWERING WITH NEW ENGLAND PLASTICS CORPORATION PROPERTY GROUNDWATER

COMPOUND	INTAKE (mg/kg/day) GEOMETRIC MEAN	MAXIMUM
trans-1,2-Dichloroethene	8.95×10^{-5}	3.08×10^{-4}
Tetrachloroethene	1.15×10^{-3}	7.68×10^{-3}
1,1,1-Trichloroethane	1.75×10^{-4}	6.59×10^{-4}
Trichloroethene	4.93×10^{-4}	1.48×10^{-3}

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

first be assessed where possible by comparing chemical concentrations found in environmental media at or near the site with applicable or relevant and appropriate requirements (ARARs) or other guidance that has been developed for the protection of human health or the environment. If ARARs are not available for all chemicals and exposures considered, quantitative risk estimates must be developed in addition to the comparison to ARARs. This section will present a comparison of exposure point concentrations to the applicable or relevant and appropriate requirements (ARARs) as well as a quantitative risk assessment.

3.3.1 COMPARISON TO APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA

In this section, the concentrations of chemicals of potential concern in groundwater at the New England Plastics property are compared to ARARs. Table 3-9 presents this comparison, and as can be seen from the table, the geometric mean and maximum concentrations of trichloroethene exceed its MCL. The geometric mean concentration of 1,1,1-trichloroethane is below its MCL while the maximum is equal to the MCL.

The geometric mean and maximum concentrations of tetrachloroethene exceed its Massachusetts drinking water standard. The geometric mean and maximum concentrations of _trans_-1,2-dichloroethene are below the Massachusetts drinking water standard. There are no ARARs for soil.

3.3.2 QUANTITATIVE RISK CHARACTERIZATION

To quantitatively assess the risks to human health associated with the future-use exposure scenarios considered in this assessment, the concentrations of chemicals in relevant environmental media (exposure point concentrations) presented in Section 3.2 are converted to chronic daily intakes (CDIs). CDIs are the amount of a substance taken into the body per unit body weight per unit time, expressed in units of mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA 1986b) and over the exposure period for noncarcinogens

TABLE 3-9

COMPARISON OF CHEMICALS OF POTENTIAL CONCERN IN THE GROUNDWATER AT
THE NEW ENGLAND PLASTICS CORPORATION PROPERTY WITH ARARS AND GUIDANCE LEVELS

(mg/liter)

Compound	Concentration		ARAR	Massachusetts Drinking Water Standard
	Geometric Mean	Maximum	MCL	
trans-1,2-Dichloroethene	0.0032	0.011	--	0.07 (a)
Tetrachloroethene	0.0494	0.33	--	0.005
1,1,1-Trichloroethane	0.0069	0.026	0.20	0.20
Trichloroethene	0.0196	0.059	0.005	0.005

(a) Proposed.

(EPA 1986c). Section 1.4.4 summarized the methodology that will be used in this section.

In this section of the risk assessment, the intakes of chemicals of potential concern by potentially exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions such as frequency and duration of exposure. For each exposure scenario evaluated, two exposure cases--an average case and plausible maximum case--are considered. For the average exposure case, geometric mean concentrations are used together with what are considered to be the most likely (although conservative) exposure conditions. For the plausible maximum case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the plausible maximum case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

Chronic daily intakes, excess lifetime cancer risks, and CDI:RfD ratios for the site-related chemicals considered in this assessment, as well as the assumptions and procedures used to calculate these values, are shown below for each scenario evaluated.

3.3.2.1 Property Under Current-Use Conditions

Inhalation of Volatiles Released During Process Related Activities. Three process wells are used at New England Plastics Corporation. The groundwater from these wells flows through troughs in the facility. Indoor air concentrations were derived in Section 3.2.1 assuming that the concentrations emitted from the large trough were the same as those emitted from the others. This may tend to over estimate exposure since the other troughs are smaller.

The assumptions used in the evaluation are summarized in Table 3-10. It is assumed that an individual works in the facility eight hours a day, five days each week, for 50 weeks a year. The individual works at this facility for 10

TABLE 3-10

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR INDOOR AIR EXPOSURE BY WORKERS AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	8 hr/day for 50 weeks/yr	8 hr/day for 50 weeks/yr
Duration of Exposure	10 yr	20 yr
Average Weight	70 kg	70 kg
Inhalation Rate	2.6 m^3/hr	2.6 m^3/hr
Average Lifetime	70 yr	70 yr

years and 20 years under average and plausible maximum exposure scenarios, respectively. Using these assumptions, chronic daily intake (CDI) estimates for inhalation of volatiles by workers at the facility can be calculated. The formulae used are presented in Section C.4 of Appendix C of this endangerment assessment. Table 3-11 presents the average and plausible maximum CDIs and the potential carcinogenic and noncarcinogenic risks associated with these exposures.

The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are 1×10^{-7} (i.e., one in ten million) and 1×10^{-6} (i.e., one in one million) for the average and plausible maximum exposure cases, respectively. Exposure to the chemicals exhibiting noncarcinogenic effects appears to represent a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, since the hazard indices are less than one.

Direct contact with contaminated soil - current workers. Under current-use conditions, industrial workers employed at the New England Plastics Corporation property could be exposed to contaminated soils. Direct contact with the contaminated soil could lead to dermal contact and absorption of contaminants through the skin, as well as inadvertent ingestion of the compounds.

Table 3-12 presents the assumptions used in assessing exposure via these pathways. These assumptions were based on the exposure pathway analysis presented in Section 3.2 and the best currently available information. EPA standard assumptions for average lifetime (70 years) and adult body weight (70 kg) were used (EPA 1985c).

Average and plausible maximum incidental ingestion rates for the workers are 25 and 100 mg/day. The derivation of these rates is discussed in Appendix C, and was based primarily on the work of Lagoy (1987).

Values of 400 mg/day and 990 mg/day are used as the average and plausible maximum estimates of soil contact rates for dermal exposure. These values are

TABLE 3-11

EXPOSURE AND RISKS ASSOCIATED WITH THE INHALATION OF VOLATILE ORGANIC COMPOUNDS RELEASED DURING INDUSTRIAL PROCESSES AT THE NEW ENGLAND PLASTICS CORPORATION

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3)		CHRONIC DAILY INTAKE 70-kg ADULT PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d)			LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	AVERAGE	PLAUSIBLE MAXIMUM
Tetrachloroethene	6.75E-04	5.16E-03	1.96E-05	3.00E-04	3.30E-03	6.5E-08	9.9E-07
Trichloroethene	2.58E-04	1.10E-03	7.51E-06	6.40E-05	4.60E-03	3.5E-08	2.9E-07
TOTAL						1E-07	1E-06

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	CONCENTRATION IN AIR (mg/m3)		CHRONIC DAILY INTAKE (CDI), 70-kg ADULT (mg/kg/d)			RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	AVERAGE	PLAUSIBLE MAXIMUM
trans-1,2-Dichloroethene	NA	2.19E-04	--	4.46E-05	1.00E-02	--	4.46E-03
Tetrachloroethene	6.75E-04	5.16E-03	1.37E-04	1.05E-03	2.00E-02	6.87E-03	5.25E-02
1,1,1-Trichloroethane	1.08E-04	3.64E-04	2.19E-05	7.40E-05	3.00E-01	7.30E-05	2.47E-04
HAZARD INDEX						<1 (0.007)	<1 (0.06)

(a) Noncarcinogens and potential carcinogens with RfDs wree evaluated for noncarcinogenic risk.

NA = Not applicable; geometric mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the size of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 3-12

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT BY WORKERS WITH SOIL AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	48 days	100 days
Duration of Exposure	10 yr	20 yr
Average Weight	70 kg	70 kg
Incidental Ingestion Rate	25 mg/days	100 mg/days
Percent of Phthalates Absorbed from Ingested Soils	15%	45%
Percent Other Organic Compounds Absorbed from Ingested Soil	100%	100%
Soil Contact Rate	400 mg/day	990 mg/day
Percent Phthalates Absorbed Dermally from Skin	0.3%	3%
Percent Other Organic Compounds Absorbed Dermally from Skin	1%	10%
Average Lifetime	70 years	70 years

contact rates for each exposure event and are based on a consideration of contact rates in mg soil/cm^2 skin (0.5-1.5 mg/cm^2) from Schaum (1984), surface area of parts of the body that are likely to be in contact with soil (e.g., approximately 840 cm^2 for the palms of the hands and 1,140 cm^2 for the forearms) from Anderson et al. (1985), and of certain subjective factors. Although these are reasonable values they have not been validated and are thus a source of uncertainty in the risk calculation.

The derivation of the absorption factors are summarized in Appendix C, Section C.3. These factors are based upon the likelihood that the chemicals will be adsorbed onto the soil (e.g., phthalate esters) and hence, be less bioavailable than these same chemicals in drinking water, for example.

Using these assumptions, chronic daily intake (CDI) estimates for incidental soil ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Appendix C, Section C.3, of this endangerment assessment. The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption. Table 3-13 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with these exposures.

The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are 7×10^{-8} (i.e., seven in one hundred million) for the average exposure case and 4×10^{-5} (i.e., four in one hundred thousand) for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

<u>Inhalation of volatiles released from contaminated soil - current workers</u>. Industrial workers at the New England Plastics Corporation property who eat lunch outside or play basketball may be exposed via inhalation to volatile organics released from the soil.

TABLE 3-13

EXPOSURES AND RISKS ASSOCIATED WITH CONTACT OF SURFACE SOILS BY WORKERS AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, PRORATED OVER 70-YR LIFETIME (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.93E+01	4.40E+04	1.94E-08	2.21E-03	6.22E-09	1.46E-03	2.56E-08	3.68E-03	8.40E-03	2.2E-10	3.1E-05
Methylene chloride	5.03E-02	9.40E+00	5.40E-11	1.05E-06	1.01E-08	1.04E-06	1.01E-08	2.09E-06	7.50E-03	7.6E-11	1.6E-08
Tetrachloroethene	3.60E-01	1.20E+03	3.86E-10	1.34E-04	1.29E-06	1.33E-04	1.29E-06	2.67E-04	5.10E-02	6.6E-08	1.4E-05
Trichloroethene	5.66E-02	1.10E+02	6.08E-11	1.23E-05	1.18E-07	1.22E-05	1.18E-07	2.45E-05	1.10E-02	1.3E-09	2.7E-07
TOTAL										7E-08	4E-05

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Acetone	NA	1.20E+02	--	5.64E-06	--	4.65E-05	--	5.21E-05	1.00E-02	--	5.21E-03
Bis(2-ethylhexyl)phthalate	1.90E+01	4.40E+04	1.34E-07	7.75E-03	4.28E-08	5.11E-03	1.77E-07	1.29E-02	2.00E-02	8.83E-06	6.43E-01
Cadmium	2.32E+00	1.70E+01	1.09E-07	7.98E-07	NAP	NAP	1.09E-07	7.98E-07	5.00E-04	2.18E-04	1.60E-03
Lead	5.26E+01	2.89E+02	2.47E-06	1.36E-05	NAP	NAP	2.47E-06	1.36E-05	6.00E-04	4.12E-03	2.26E-02
Methylene chloride	5.03E-02	9.40E+00	2.36E-09	4.41E-07	7.94E-07	3.64E-06	7.96E-07	4.08E-06	6.00E-02	1.33E-05	6.81E-05
Tetrachloroethene	3.62E-01	1.20E+03	1.70E-08	5.64E-05	5.71E-06	4.65E-04	5.73E-06	5.21E-04	2.00E-02	2.86E-04	2.61E-02
1,1,1-Trichloroethane	1.94E-02	1.30E+01	9.11E-10	6.11E-07	3.06E-07	5.04E-06	3.07E-07	5.65E-06	9.00E-02	3.41E-06	6.28E-05
HAZARD INDEX										<1 (0.005)	<1 (0.7)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NAP = Not applicable; dermal absorption assumed to be negligible for inorganic compounds.
NA = Not applicable; mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the size of the number).
A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

The assumptions used to assess exposure via this pathway are summarized in Table 3-14. The frequency and duration of exposure are those developed under the direct contact scenario. EPA standard assumptions for average lifetime (70 years), adult body weight (70 kg) and average adult breathing rate for moderate activity were used (EPA 1985c).

Table 3-15 presents the average and plausible maximum CDIs and potential carcinogenic and noncarcinogenic risks associated with these exposures. The upperbound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are $3x10^{-13}$ (i.e., three in ten trillion) and $1x10^{-9}$ (i.e., one in one billion) for the average and plausible maximum exposure cases, respectively. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the condition of both average and plausible maximum exposures, since the hazard indices are both less than one.

3.3.2.2 Property Under Future-Use Conditions

In the absence of institutional controls limiting access of future uses of the New England Plastics property, there are additional exposure pathways that must be evaluated. It is possible that in the future, construction activities or excavations for utilities would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short term compared with either the scenario developed in Section 3.3.2.1 for current industrial workers or the scenario developed below for future residents, and thus this short term exposure scenario will not be quantified.

Direct contact with contaminated soil - future residents. If the New England Plastics Corporation property were redeveloped for residential purposes, the potential exists for residents living on the property to be exposed to contaminated soils during outdoor activities. Table 3-16 summarizes the average and plausible maximum exposure assumptions used in this evaluation. These assumptions are derived from the same sources as mentioned above for the current-use direct contact scenario, but differ in that they are average

TABLE 3-14

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR OUTDOOR INHALATION EXPOSURE OF INDUSTRIAL WORKERS AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	1 hr/d	1 hr/d
Duration of Exposure	48 d/yr	100 d/yr
Length of Employment	10 yr	20 yr
Inhalation Rate	2.6 m^3/hr	2.6 m^3/hr
Average Body Weight	70 kg	70 kg
Average Lifetime	70 yr	70 yr

TABLE 3-15

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINANTS RELEASED FROM SURFACE SOILS BY WORKERS AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	MAXIMUM	CHRONIC DAILY INTAKE 70-kg ADULT PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	4.61E-14	1.07E-11	3.47E-17	3.34E-14	8.40E-03	2.9E-19	2.8E-16
Methylene chloride	1.73E-08	3.23E-06	1.30E-11	1.01E-08	1.40E-02	1.8E-13	1.4E-10
Tetrachloroethene	2.28E-08	7.62E-05	1.72E-11	2.38E-07	3.30E-03	5.7E-14	7.9E-10
Trichloroethene	4.40E-09	8.55E-06	3.31E-12	2.68E-08	4.60E-03	1.5E-14	1.2E-10
TOTAL						3E-13	1E-09

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	MAXIMUM	CHRONIC DAILY INTAKE (CDI), 70-kg ADULT (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	PLAUSIBLE MAXIMUM
Acetone	NA	3.12E-06	NA	3.42E-08	3.00E+00	NA	1.14E-08
Bis(2-ethylhexyl)phthalate	4.61E-14	1.07E-11	2.43E-16	1.17E-13	2.00E-02	1.21E-14	5.85E-12
Methylene chloride	1.73E-08	3.23E-06	9.10E-11	3.54E-08	6.00E-02	1.52E-09	5.90E-07
Tetrachloroethene	2.28E-08	7.62E-05	1.20E-10	8.35E-07	2.00E-02	6.01E-09	4.17E-05
1,1,1-Trichloroethane	3.86E-09	2.59E-06	2.03E-11	2.84E-08	3.00E-01	6.77E-11	9.45E-08
HAZARD INDEX						<1 (8E-09)	<1 (4E-05)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
NA = Not applicable; mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 3-16

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT BY FUTURE RESIDENTS WITH SOIL AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 d/yr	168 d/yr
Duration of Exposure	70 yr	70 yr
Average Weight	70 kg	70 kg
Incidental Ingestion Rate[a]	54 mg/d	145 mg/d
Percent Phthalates Absorbed from Ingested Soils	15%	45%
Percent Other Organic Compounds Absorbed from Ingested Soils	100%	100%
Soil Contact Rate[a]	0.79 g/d	5.4 g/d
Percent Phthalates Absorbed Dermally from Skin	0.3%	3%
Percent Other Organic Compounds Absorbed Dermally from Skin	1%	10%
Average Lifetime	70 years	70 years

[a] Based on a lifetime average.

lifetime exposures. Time-weighted averages for the amount of soil ingested per exposure event and the dermal soil contact rate were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime.

Using these assumptions, chronic daily intake (CDI) estimates for incidental soil ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Appendix C of this endangerment assessment. The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption. Table 3-17 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with these exposures.

The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are 1×10^{-8} (i.e., one in one hundred million) for the average exposure case and 8×10^{-4} (i.e., eight in ten thousand) for the plausible maximum exposure case. Under the conditions of the average case, exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability since the ratios of the CDI:RfD are below one and the hazard index is below one. However, under the plausible maximum scenario, the hazard index exceeds one primarily because of exposure to bis(2-ethylhexyl)phthalate. A hazard index greater than one suggests that exposure may be associated with adverse health effects.

<u>Inhalation of volatiles - future residents</u>. In addition to direct contact with contaminated soil, residents could be exposed to chemicals volatilizing from soil while they are out of doors. Table 3-18 summarizes the average and plausible maximum exposure assumptions used in this evaluation. A time-weighted average inhalation rate for moderate activity (EPA 1985c) was used to evaluate exposure. It should be noted that this scenario does not consider inhalation exposure of volatiles which could migrate from outdoors into the home. Thus, in terms of total exposure, this scenario may underestimate exposure and risk.

TABLE 3-17

EXPOSURES AND RISKS ASSOCIATED WITH CONTACT OF SURFACE SOILS BY FUTURE RESIDENTS AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.90E+01	4.40E+04	6.02E-07	1.89E-02	1.76E-07	4.69E-02	7.79E-07	6.57E-02	8.40E-03	6.5E-09	5.5E-04
Methylene chloride	5.03E-02	9.40E+00	1.06E-08	8.96E-06	1.56E-09	3.34E-05	1.22E-08	4.23E-05	7.50E-03	9.1E-11	3.2E-07
Tetrachloroethene	3.60E-01	1.20E+03	7.61E-08	1.14E-03	1.11E-08	4.26E-03	8.72E-08	5.40E-03	5.10E-02	4.4E-09	2.8E-04
Trichloroethene	5.66E-02	1.10E+02	1.20E-08	1.05E-04	1.75E-09	3.91E-04	1.37E-08	4.95E-04	1.10E-02	1.5E-10	5.4E-06
TOTAL										1E-08	8E-04

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Acetone	NA	1.20E+02	--	1.14E-04	--	4.26E-04	--	5.40E-04	1.00E-02	--	5.40E-02
Bis(2-ethylhexyl)phthalate	1.90E+01	4.40E+04	6.02E-07	1.89E-02	1.76E-07	4.69E-02	7.79E-07	6.57E-02	2.00E-02	3.89E-05	3.29E+00
Cadmium	2.30E+00	1.70E+01	4.86E-07	1.62E-05	NAP	NAP	4.86E-07	1.62E-05	5.00E-04	9.72E-04	3.24E-02
Lead	5.26E+01	2.89E+02	1.11E-05	2.76E-04	NAP	NAP	1.11E-05	2.76E-04	6.00E-04	1.85E-02	4.59E-01
Methylene chloride	5.03E-02	9.40E+00	1.06E-08	8.96E-06	1.56E-09	3.34E-05	1.22E-08	4.23E-05	6.00E-02	2.03E-07	7.06E-04
Tetrachloroethene	3.60E-01	1.20E+03	7.61E-08	1.14E-03	1.11E-08	4.26E-03	8.72E-08	5.40E-03	2.00E-02	4.36E-06	2.70E-01
1,1,1-Trichloroethane	1.94E-02	1.30E+01	4.10E-09	1.24E-05	6.00E-10	4.62E-05	4.70E-09	5.86E-05	9.00E-02	5.22E-08	6.51E-04
HAZARD INDEX										<1 (0.02)	>1 (4)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NAP = Not applicable; dermal absorption of inorganics through the skin is negligible.
NA = Not applicable; mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the size of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 3-18

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR OUTDOOR INHALATION EXPOSURE BY FUTURE RESIDENTS AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	1 hr/day	3 hr/day
Duration of Exposure	100 d/yr	168 d/yr
Inhalation Rate[a]	2.1 m^3/hr	2.1 m^3/hr
Average Weight	70 kg	70 kg
Average Lifetime	70 yr	70 yr

[a] Based on a lifetime average.

The average and plausible maximum CDIs and potential risks associated with exposure via this pathway are summarized in Table 3-19. The potential upperbound excess lifetime cancer risk is $3x10^{-12}$ (i.e., three in one trillion) for average exposure conditions and $1x10^{-8}$ (i.e., one in one hundred million) for plausible maximum exposure conditions. Exposure to the noncarcinogenic compounds appears to represent a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, since the hazard indices are less than one.

Ingestion of groundwater - future residents. Under this future-use scenario, it is assumed that there are no future remedial actions and institutional actions limiting access to the use of the groundwater. Hence, individuals could be exposed to groundwater contaminants by direct ingestion of tap water. The average individual is assumed to weigh 70 kg and drink 2 liters of water each day for 70 years (an average lifetime). Based on these assumptions, and the existing chemical concentrations in the groundwater, chronic daily intakes were derived and are presented in Table 3-20. The risks associated with these intake levels are also presented for chemicals potentially exhibiting carcinogenic and noncarcinogenic effects.

The upper bound lifetime excess cancer risks associated with ingestion are $8x10^{-5}$ (i.e., eight in one hundred thousand) and $5x10^{-4}$ (i.e., five in ten thousand) for the average and plausible maximum cases, respectively. The hazard index for the average exposure scenario is less than one indicating a low probability of adverse health effects. Under the plausible maximum exposure scenario, the CDI:RfD ratios for the individual chemicals of potential concern and the hazard index are all below one.

Inhalation of contaminants while showering. In addition to ingestion of groundwater, inhalation of volatilized contaminants can occur while using the water for nonconsumptive uses. Exposure to individuals while showering is quantified here. The shower model of Foster and Chrostowski (1987), discussed in Appendix C, Section C.2, was used to quantify exposure via this pathway. The potential health risks associated with the estimated inhalation exposures while showering are presented in Table 3-21. It should be noted that while

TABLE 3-19

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINANTS RELEASED FROM SURFACE SOILS BY RESIDENTS AT THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE 70-kg ADULT PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE 70-kg ADULT PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	4.61E-14	1.07E-11	3.80E-16	4.44E-13	8.40E-03	3.2E-18	3.7E-15
Methylene chloride	1.73E-08	3.23E-06	1.43E-10	1.34E-07	1.40E-02	2.0E-12	1.9E-09
Tetrachloroethene	2.28E-08	7.62E-05	1.88E-10	3.16E-06	3.30E-03	6.2E-13	1.0E-08
Trichloroethene	4.40E-09	8.55E-06	3.63E-11	3.55E-07	4.60E-03	1.7E-13	1.6E-09
TOTAL						3E-12	1E-08

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (CDI), 70-kg ADULT (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI), 70-kg ADULT (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Acetone	NA	3.12E-06	NA	1.30E-07	3.00E+00	NA	4.32E-08
Bis(2-ethylhexyl)phthalate	4.61E-14	1.07E-11	3.80E-16	4.44E-13	2.00E-02	1.90E-14	2.22E-11
Methylene chloride	1.73E-08	3.23E-06	1.43E-10	1.34E-07	6.00E-02	2.38E-09	2.24E-06
Tetrachloroethene	2.28E-08	7.62E-05	1.88E-10	3.16E-06	2.00E-02	9.42E-09	1.58E-04
1,1,1-Trichloroethane	3.86E-09	2.59E-06	3.18E-11	1.08E-07	3.00E-01	1.06E-10	3.58E-07
HAZARD INDEX						<1 (1E-08)	<1 (2E-04)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
NA = Not applicable; mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 3-20

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER AT NEW ENGLAND PLASTICS PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	PLAUSIBLE MAXIMUM
Tetrachloroethene	49.4	330	1.41E-03	9.43E-03	5.10E-02	7.2E-05	4.8E-04
Trichloroethene	19.6	59.0	5.60E-04	1.69E-03	1.10E-02	6.2E-06	1.9E-05
TOTAL	--	--	--	--	--	8E-05	5E-04

B. NONCARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	MAXIMUM	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	PLAUSIBLE MAXIMUM
trans-1,2-Dichloroethene	3.2	11	9.14E-05	3.14E-04	1.00E-02	9.1E-03	3.1E-02
Tetrachloroethene	49.4	330	1.41E-03	9.43E-03	2.00E-02	7.1E-02	4.7E-01
1,1,1-Trichloroethane	6.9	26	1.97E-04	7.43E-04	9.00E-02	2.2E-03	8.3E-03
HAZARD INDEX	--	--	--	--	--	<1 (0.08)	<1 (0.5)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 3-21

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VAPORS WHILE SHOWERING WITH GROUNDWATER FROM THE NEW ENGLAND PLASTICS CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR $(mg/kg/d)^{-1}$	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	PLAUSIBLE MAXIMUM
Tetrachloroethene	1.15E-03	7.68E-03	3.30E-03	3.8E-06	2.5E-05
Trichloroethene	4.93E-04	1.48E-03	4.60E-03	2.3E-06	6.8E-06
TOTAL	--	--	--	6E-06	3E-05

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	PLAUSIBLE MAXIMUM
trans-1,2-Dichloroethene	8.95E-05	3.08E-04	1.00E-02	8.9E-03	3.1E-02
Tetrachloroethene	1.15E-03	7.68E-03	2.00E-02	5.7E-02	3.8E-01
1,1,1-Trichloroethane	1.75E-04	6.59E-04	3.00E-01	5.8E-04	2.2E-03
HAZARD INDEX	--	--	--	<1 (0.07)	<1 (0.4)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

the chronic daily intake for exposure to volatile organic contaminants in groundwater via ingestion and inhalation are comparable, as expected from the literature (Foster and Chrostowski 1987, McKone 1987, EPA 1984i), the risks from this exposure will vary due to differences in the oral and inhalation potency factors.

The excess lifetime upper bound cancer risks associated with the average and plausible maximum cases were 6×10^{-6} (i.e., six in one million) and 3×10^{-5} (i.e., three in one hundred thousand), respectively. For chemicals exhibiting noncarcinogenic effects, the individual CDI:RfD ratios for each compound under both average and plausible maximum conditions were below one as was the corresponding hazard index.

3.3.3 MULTIMEDIA EXPOSURES

Exposure via one of the pathways discussed above for the future-use scenarios does not preclude exposures via other pathways. For example, residents of the area may be exposed to contaminated soil and contaminated tap water. Exposure by one route generally dominates the exposure and risk calculations, and by adding exposures from other routes is unlikely to have a substantial effect on risks. For example, under the average future-use scenario, the upper bound excess lifetime cancer risk associated with direct contact with soil is 2×10^{-6} and inhalation of volatiles released from soil is 2×10^{-10}. The upper bound lifetime cancer risk associated with the inhalation of vapors released while showering is 6×10^{-6}, and that associated with the ingestion of groundwater is 4×10^{-4}. The sum of these three values is approximately equal to the risk value associated with ingestion of groundwater alone. Therefore, in this situation, the quantitative risk is dominated by only one type of exposure and it may be concluded that groundwater is the medium of most concern from the human health standpoint.

3.4 SUMMARY OF NEW ENGLAND PLASTICS CORPORATION PROPERTY EVALUATION

This section of the Endangerment Assessment for the New England Plastics Corporation property is a baseline assessment, which evaluates potential impacts to human health in the absence of further remedial actions under both current- and future-use scenarios. Chemicals of potential concern were selected based on the sampling data of the environmental media and consideration of toxicity. Soil chemicals of potential concern were acetone, bis(2-ethylhexyl)phthalate, cadmium, lead, methylene chloride, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene. The groundwater chemicals of potential concern were trans-1,2-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene.

Under current land-use conditions at the New England Plastics Corporation property, the principal exposure pathways by which human receptors could potentially be exposed to site contaminants were direct contact of industrial workers with surface soils, inhalation of volatiles released from soils, and inhalation of volatiles released from the process water. Average and plausible maximum exposure scenarios were developed for this pathway. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed population. Human health risks were assessed based on these estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of workers to volatiles released from the water used in the production process could result in potential excess upper bound lifetime cancer risks of $1x10^{-7}$ for the average exposure case and $2x10^{-6}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of workers to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $7x10^{-8}$ for the average exposure case and $4x10^{-5}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of workers to volatiles released from contaminated soil could result in potential upperbound lifetime excess cancer risks of $3x10^{-13}$ and $1x10^{-9}$ for the average and plausible maximum exposure cases, respectively. The hazard indices are both less than one for the average and plausible maximum cases.

The exposure scenario described above would apply for future land-use conditions as well. In addition, exposure pathways related to residential soil exposure and to uses of the groundwater were considered. The groundwater uses included ingestion of groundwater and inhalation of volatile organic chemicals released while showering. Average and plausible maximum exposure scenarios were developed. The conclusions are as follows:

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of 1×10^{-8} for the average exposure case and 8×10^{-4} for the plausible maximum exposure case. Under the conditions of the average case, the ratios of the CDI:RfD are below one and the hazard index is below one. However, under the plausible maximum scenario, the hazard index exceeds one.

- Inhalation of volatiles released from contaminated soil could result in potential upperbound lifetime excess cancer risks of 3×10^{-12} for average exposure conditions and 1×10^{-8} for plausible maximum exposure conditions. The hazard indices were less than one for both the average and plausible maximum cases.

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of 8×10^{-5} and 5×10^{-4} for the average and plausible maximum cases, respectively. The hazard index was less than 1 for both the average and plausible maximum cases.

- Inhalation of volatiles released from the groundwater while showering could result in 6×10^{-6} and 3×10^{-5} potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for both the average and plausible maximum cases.

4.0 OLYMPIA NOMINEE TRUST COMPANY

The Olympia Nominee Trust Company property covers 21 acres of land in the northern section of the Wells G & H site study area west of the W.R. Grace Company property. This property was and still is used for transportation and trucking operations. Diesel and gasoline fuels are stored in underground tanks on the site. An underground gasoline storage tank leak in the trucking area and a pile of drums on the southwest portion of the site were identified. The leaking gasoline storage tank was removed in 1986; the resulting groundwater contamination is being investigated by the Commonwealth of Massachusetts. Drums and some surrounding soil were investigated and removed in both 1986 and 1987 under orders issued by the EPA. The property is presently being leased to United Truck Leasing Corporation.

4.1 CHEMICALS OF POTENTIAL CONCERN

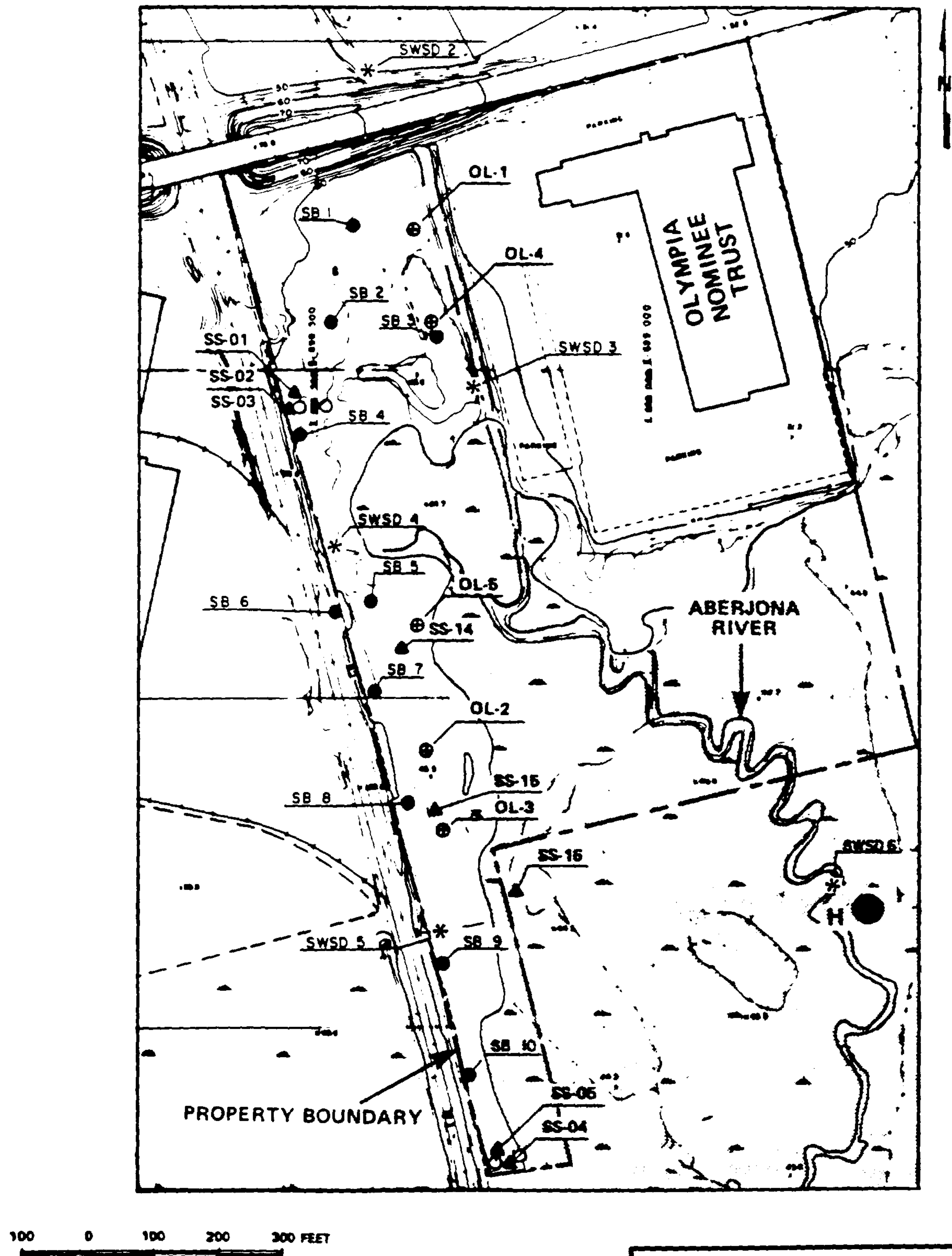
The basis for the selection of chemicals of potential concern is outlined in Appendix A of this document. Validated analytical data collected during the Ebasco supplementary remedial investigation and the methodology presented in the Superfund Public Health Evaluation manual (EPA 1986a) were used to evaluate the nature and extent of contamination and to select the chemicals which pose the greatest threat to human health and the environment. The Aberjona River and wetlands are adjacent to this property and some sampling data are available. Discussion of these areas will be treated together in the nonsource area section of this report (Section 7) and the ecological risk assessment in Section 8.

4.1.1 SOIL

Soil sampling on the Olympia Nominee Trust property conducted as part of removal operations in 1985 and 1986 revealed the presence of organic compounds. Contaminated soil and drums were excavated and removed from the site in 1986 and 1987. Soil samples collected during the supplemental RI (Ebasco 1988a) will be used to select chemicals of potential concern since these data reflect conditions at this property as they currently exist. Figure 4-1 shows the sampling locations.

The surface soil sampling data (complete data tables are presented in Appendix E) reveal that sampling point OL-SS04 contained the most organic constituent contamination. The polynuclear aromatic hydrocarbons (PAHs) detected at this sampling location are summarized in Table 4-1 along with their concentrations. Both the potentially carcinogenic and noncarcinogenic PAHs will be considered in this assessment. The toxicity of carcinogenic PAHs is well established whereas there is relatively little data on PAHs which show non-carcinogenic effects. For example, naphthalene is the only non-carcinogenic PAH for which EPA has derived an RfD. All of the noncarcinogenic PAHs will be evaluated assuming that each has the same RfD as naphthalene. The potentially carcinogenic and noncarcinogenic PAHs are summed separately to determine the total concentration of each class present at this property. The geometric mean concentration is the mean of the totals rather than the sum of the geometric mean concentration of each PAH found in the soil. Thus, the total geometric mean concentration in Table 4-1 will not equal the sum of the individual PAHs.

The pesticides detected at this location are 4,4'-DDT and its degradation products 4,4'-DDD and 4,4'-DDE which will be treated together since there is only toxicity information on 4,4'-DDT. The other sampling locations contained low (below 100 ug/kg for the most part) or nondetectable levels of the organic constituents. The subsurface soils generally contained different organic compounds, as seen in Table 4-1. Here, volatile organics were the primary contaminants detected. It is likely that at these low levels (i.e., near the detection limit), the data are revealing degassing levels from the groundwater, as opposed to actual soil contamination and are therefore not considered as chemicals of potential concern. To summarize, the organic chemicals of potential concern for the soils at the Olympia property are carcinogenic and noncarcinogenic PAHs and 4,4'-DDT and its degradation products.



● SB1 – SOIL BORING LOCATION AND NUMBER
⊕ OL-1 – WELL BORING LOCATION AND NUMBER
▲ SS-01 – SURFACE SOIL LOCATION AND NUMBER
* SWSD3 – SURFACE WATER SEDIMENT LOCATION AND NUMBER
— — — PROPERTY BOUNDARY
OO APPROXIMATE SEWER MANHOLE LOCATIONS
☐ WETLANDS

U.S. ENVIRONMENTAL PROTECTION AGENCY

WELLS G & H

Figure 4-1

OLYMPIA PROPERTY SOIL SAMPLING LOCATIONS

EBASCO SERVICES INCORPORATED

TABLE 4-1

COMPOUNDS DETECTED IN SOIL AT OLYMPIA PROPERTY OF WELLS G & H SITE

COMPOUND	SURFACE SOIL			SUBSURFACE SOIL		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/kg)						
VOLATILES						
BENZENE	ND			1/20	NR	2.00
CHLOROFORM	1/11	2.60	4.00	3/20	2.55	4.00
TRANS-1,2-DICHLOROETHENE	ND			1/19	NA	4.00
METHYLENE CHLORIDE	ND			1/5	NA	7.00
TETRACHLOROETHENE	ND			4/20	2.86	9.00
TOLUENE	ND			2/20	NR	2.00
1,1,1-TRICHLORETHANE	1/15	2.60	5.00	ND		
TRICHLOROETHENE	1/15	2.70	8.00	4/20	3.09	19.0
SEMI-VOLATILES						
ACENAPHTHYLENE	1/15	NA	440	ND		
ANTHRACENE	1/14	NA	320	ND		
BENZOIC ACID	1/15	NA	210	ND		
BENZO(A)ANTHRACENE	6/15	60.9	590	2/20	NR	1.00
BENZO(A)PYRENE	4/15	90.1	520	1/20	NR	6.00
BENZO(B)FLUORANTHENE	5/15	70.0	1100	1/20	NR	10.0
BENZO(g,h,i)PERYLENE	3/15	118	230	ND		
BENZO(K)FLUORANTHENE	1/15	NA	250	1/20	NA	370
BIS(2-ETHYLHEXYLPHTHALATE	2/10	NR	5.00	4/20	NR	89.0
BUTYLBENZYL PHTHALATE	1/14	NR	1.00	ND		
CHRYSENE	5/13	42.3	630	2/20	NR	15.0
DIBENZ(A,H)ANTHRACENE	1/15	NR	3.00	ND		
3,3-DICHLOROBENZIDINE	1/15	NR	2.00	ND		
DIETHYL PHTHALATE	1/15	NR	0.40	ND		
DI-N-BUTYL PHTHALATE	6/13	NR	7.00	6/20	NR	5.00
FLUORANTHENE	4/11	50.8	1100	ND		
FLUORENE	1/15	NR	18.0	ND		
INDENO(1,2,3-CD)PYRENE	1/14	NR	3.00	ND		
2-METHYLNAPHTHALENE	ND			1/20	NR	6.00
NAPHTHALENE	ND			2/20	156	980
PHENANTHRENE	3/13	NR	2.00	2/20	NR	
PYRENE	5/12	39.0	850	ND		
1,2,4-TRICHLOROBENZENE	ND			1/20	NR	73.0
CARCINOGENIC PAHS, TOTAL	7/15	31.3	3410	3/20	4.00	401
NONCARCINOGENIC PAHS, TOTAL	7/15	16.9	2620	3/20	25.0	980
PESTICIDES/PCBS/DIOXINS						
4,4'-DDT	1/15	NA	240	ND		
4,4'-DDD	1/15	NA	38.0	ND		
4,4'-DDE	2/15	10.3	88.0	ND		
CHLORDANE	ND			2/20	9.18	46.0
HpCDD	1/3	NA	1.17	ND		
OCDD	1/3	NA	16.54	ND		
OCDF	1/3	NA	6.70	ND		

ND = Not Detected.

NA = Not applicable; mean not calculated with only one positive detect.

NR = Not reported. Compound was detected infrequently, and geometric mean was calculated to be greater than the maximum detected value. Therefore, mean was not used.

TABLE 4-1 (continued)

COMPOUNDS DETECTED IN SOIL AT OLYMPIA PROPERTY OF WELLS G & H SITE

COMPOUND	SURFACE SOIL			SUBSURFACE SOIL		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
INORGANICS (mg/kg)						
ALUMINUM	15/15	7550	15300	20/20	5640	27900
ARSENIC	15/15	9.80	139	19/20	6.02	24.0
BARIUM	15/15	42.7	2000	18/20	15.3	109
BERYLLIUM	5/15	0.55	1.10	8/20	0.14	0.25
CADMIUM	1/15	NA	3.20	6/20	0.39	2.20
CALCIUM	15/15	1180	30000	19/20	793	4430
CHROMIUM	14/15	20.3	924	20/20	12.7	383
COBALT	3/15	4.63	5.5	10/20	3.31	19.0
COPPER	14/15	12.4	68.0	18/20	10.2	143
IRON	15/15	9180	36400	20/20	6560	37400
LEAD	15/15	23.8	424	19/20	8.63	122
MAGNESIUM	15/15	1950	5780	20/20	1470	12000
MANGANESE	15/15	113	285	20/20	69.9	524
MERCURY	8/15	0.07	0.80	7/20	0.03	4.20
NICKEL	10/15	6.32	27.0	13/20	4.98	37.0
POTASSIUM	15/15	639	2210	20/20	469	3530
SELENIUM	ND			1/20	NA	1.20
SILVER	1/15	NA	5.20	1/20	NA	2.40
SODIUM	15/15	98.2	271	11/20	141	301
VANADIUM	15/15	14.0	39.0	19/20	8.65	69.0
ZINC	14/15	33.4	486	20/20	19.2	83.0

NA = Not applicable; mean not calculated with only one positive detect.

ND = Not Detected.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE A GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

Three soil samples were collected and analyzed for the polychlorinated dibenzo-p-dioxins (PCDDs), as seen on Figure 4-1. In sampling location, D8, heptachlorodibenzo-p-dioxin (HpCDD) and octachlorodibenzo-p-dioxin (OCDD) were detected at concentrations of 1.2 ng/g and 16.5 ng/g, respectively. These two compounds are members of the PCDD family of compounds, the most biologically active of which is 2,3,7,8-tetrachlorordibenzo-p-dioxin (2,3,7,8-TCDD) which was not detected here. For regulatory purposes, the relative potencies of the other PCDDs are often based on a comparison with 2,3,7,8-TCDD. Based on the equivalency method for evaluating PCDDs (discussed in Appendix A), the total 2,3,7,8-TCDD equivalent concentration is 0.0012 ng/g which is well below the 1 ng/g typical soil action levels for this class of compounds (Kimbrough 1984, EPA 1988d). Thus, these two compounds were not selected as chemicals of potential concern.

Most of the inorganic constituents detected in the soil were found at levels within background ranges as seen in Table A-1 of Appendix A. Arsenic, barium, chromium, lead, and zinc were found at levels exceeding background. Arsenic and barium were not selected as chemicals of potential concern because their geometric mean concentrations fell within the Massachusetts (Shacklette and Boerngen 1984) and regional (Connor and Shacklette 1975) background ranges and the maximum fell within the range of twice the maximum background concentrations. Zinc was not selected as a chemical of concern because it is an essential nutrient and the concentration fell within the criteria used to screen out these chemicals. Chromium and lead were selected as chemicals of concern for soils at the Olympia Nominee Trust property.

4.1.2 GROUNDWATER

The groundwater sampling performed at the Olympia Nominee Trust Co. property during both RIs was used to evaluate the nature and extent of groundwater contamination. As seen in Table 4-2, relatively low levels of contamination are found in the groundwater for most of the chemicals detected. Trichloroethylene was detected the most frequently and in the highest concentrations of the volatile organic compounds and is selected as a chemical of potential concern. Other volatile organic compounds detected more than

TABLE 4-2

COMPOUNDS DETECTED IN GROUNDWATER AT THE OLYMPIA NOMINEE TRUST COMPANY PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/liter)			
ACENAPHTHENE	1/9	NA	13.0
ACENAPTHYLENE	1/9	NA	7.00
BENZENE	2/15	2.65	5.00
BIS(2-ETHYLHEXYL) PHTHALATE	2/7	6.20	14.0
2-BUTANONE	1/13	NA	35.0
CHLORDANE	1/9	NA	1.20
1,1-DICHLOROETHANE	4/14	2.61	6.00
TRANS-1,2-DICHLOROETHENE	2/11	2.81	23.0
ETHYLBENZENE	1/16	NA	5.00
2-METHYLNAPHTHALENE	1/9	NA	5.00
NAPHTHALENE	2/9	5.95	120
PHENANTHRENE	1/9	NA	6.00
1,1,2,2-TETRACHLOROETHANE	1/16	NA	10.0
TETRACHLOROETHENE	5/10	6.10	45.0
TOLUENE	1/10	NA	5.00
1,1,1-TRICHLOROETHANE	1/15	NA	2.50
TRICHLOROETHENE	10/13	20.9	3400
TOTAL XYLENES	3/16	4.88	170
NONCARCINOGENIC PAHs, TOTAL	3/9	7.60	151
INORGANICS (ug/liter)			
ARSENIC	3/3	9.9	16.4
BARIUM	3/3	26.9	55.6
CALCIUM	3/3	30600	50900
IRON	3/3	1960	6040
MAGNESIUM	3/3	6510	12900
MANGANESE	3/3	1370	4170
POTASSIUM	3/3	3340	3690
SODIUM	3/3	45000	77900
ZINC	3/3	18.4	25.4

NA = Not applicable; mean not calculated with only one positive detection.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

once and selected as chemicals of potential concern were 1,1-dichloroethane, trans-1,2-dichloroethene, and tetrachloroethene. Total xylenes were detected in 3 of 16 samples and although the presence of these compounds is due to the gasoline spill which is under the jurisdiction of the Commonwealth of Massachusetts, xylene will be selected as a chemical of concern. Bis(2-ethylhexyl)phthalate was detected in 2 of 7 samples and will be selected as a chemical of potential concern. Several PAHs were detected in the groundwater but all are considered to be noncarcinogens. Due to the low levels detected (i.e., near the detection limit), these chemicals will not be considered to be chemicals of potential concern.

The inorganic constituents detected in the groundwater, with the exception of arsenic and manganese, were present below background levels. These two inorganic compounds will be selected as chemicals of potential concern for the Olympia property. It should be noted, however, that the geometric mean and maximum concentrations of sodium exceeded the Massachusetts advisory level of 20,000 ug/liter for persons on salt restricted diets.

4.1.3 SUMMARY

The chemicals of potential concern for the soil at the Olympia Nominee Trust Company property are the carcinogenic PAHs and the noncarcinogenic PAHs, chromium, 4,4'-DDT and its degradation products, and lead. The groundwater chemicals of potential concern are arsenic, bis(2-ethylhexyl)phthalate, 1,1-dichloroethane, trans-1,2-dichloroethene, manganese, tetrachloroethene, trichloroethene, and total xylenes. Table 4-3 summarizes this information.

4.2 EXPOSURE ASSESSMENT

4.2.1 PROPERTY UNDER CURRENT-USE CONDITIONS

Under current-use conditions, exposure related to contamination originating in the soil will be considered. The contaminated soil at this property can act as a source of contaminants to the air via volatilization of organic compounds or through fugitive dust generation. Conditions at the Olympia Nominee Trust

TABLE 4-3

CHEMICALS OF POTENTIAL CONCERN FOR THE OLYMPIA NOMINEE TRUST PROPERTY

SOIL	GROUNDWATER
Chromium	Arsenic
4,4'-DDT[a]	Bis(2-ethylhexyl)phthalate
Lead	1,1-Dichloroethane
carcinogenic PAHs[b]	trans-1,2-Dichloroethene
noncarcinogenic PAHs[c]	Manganese
	Tetrachloroethene
	Trichloroethene
	Total Xylenes

[a] 4,4'-DDT and its degradation products, 4,4'-DDD and 4,4'-DDE.

[b] The carcinogenic PAHs included here are: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-c,d)perylene.

[c] The noncarcinogenic PAHs included here are: acenaphthylene, anthracene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

property do not favor the release of volatile contaminants because this area is well vegetated, with the exception of the unpaved trail which is used for dirt bike riding. In addition, the soil organic chemicals of potential concern have a tendency to remain sorbed onto soil particles rather than to volatilize into the air. The release of fugitive dust is, however, considered to be a potential exposure pathway since young adults have been observed riding dirt bikes over the unvegetated portions of the site.

Industrial and maintenance workers are currently employed and present at the few companies located within the trucking terminal on the east side of the river. The worker population at this business is likely to remain indoors most of the day. The area adjacent to the building is paved. The area on the west side of the river is unpaved, vegetated, and where the contamination is found. It is possible that workers could go across the bridge over the Aberjona River and have lunch in this area for one hour each day. Thus, these individuals could be exposed to contaminated soils via dermal absorption from or incidental ingestion of contaminated soils. It is assumed that for the average case scenario, an individual will be outdoors three days a week for four months or 48 days per year for 10 years. For the plausible maximum exposure scenario, an individual would be outdoors for five days each week for five months or 100 days per year for 20 years of employment. The soil concentrations an individual could be exposed to are summarized in Table 4-4.

Young adults are known to use a portion of the Olympia Nominee Trust property to ride dirt bikes. Exposure to these individuals will be evaluated in this endangerment assessment. The pathways considered here will be inhalation of contaminated dust particles generated while riding dirt bikes and direct contact with soil. The latter pathway will include both incidental ingestion of soil as well as dermal absorption of contaminants through the skin. The methodology used to evaluate exposure is presented in Appendix C, Section C.3. Under average exposure conditions, it is assumed that an individual will be at this property five days per week for four months or 100 days per year for six years. Under plausible maximum conditions, an individual is assumed to frequent the site seven days per week for six months or 168 days per year,

TABLE 4-4

SOIL AND DUST CONCENTRATIONS OF THE CHEMICALS OF POTENTIAL CONCERN FOR THE OLYMPIA NOMINEE TRUST PROPERTY

Compound	Surface Soil Concentration (mg/kg)[a] Geometric Mean	Surface Soil Concentration (mg/kg)[a] Maximum	Dust Concentration (mg/m^3)[a] Geometric Mean	Dust Concentration (mg/m^3)[a] Maximum
Chromium	20.3	924	5.72×10^{-7}	2.60×10^{-5}
4,4'-DDT[a]	2.93×10^{-2}	0.37	8.31×10^{-10}	1.03×10^{-8}
Lead	23.8	424	6.70×10^{-7}	1.19×10^{-5}
cPAHs[b]	3.13×10^{-2}	3.41	8.82×10^{-10}	9.61×10^{-8}
nPAHs[c]	1.69×10^{-2}	2.62	4.76×10^{-10}	7.38×10^{-8}

[a] The reported concentration of 4,4'-DDT includes the concentrations of its degradation products, 4,4'-DDD and 4,4'-DDE.

[b] The carcinogenic PAHs included here are: anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene and indeno(1,2,3-c,d)perylene.

[c] The noncarcinogenic PAHs included here are: acenaphthylene, benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene, and pyrene.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

also for six years. The concentrations of the chemicals of potential concern in the soil are presented in Table 4-4.

Dust can be generated during dirt bike riding and inhaled by the bike rider or by other individuals present adjacent to the trail. For this exposure scenario, it is assumed that four dirt bike riders use the property at the same frequency as discussed above for the direct contact with soil scenario. The methodology used to evaluate this scenario is summarized in Appendix C, Section C.4, and is derived from that of Cowherd et al. (1984). Table 4-4 also presents the concentrations of the chemicals of potential concern found in dust resulting from this scenario.

Groundwater is not currently used for drinking water purposes; thus, this pathway is not complete under current conditions and will not be evaluated here. As was stated above, exposure to surface water and sediments will be evaluated in the nonsource area section of this endangerment assessment.

4.2.2 PROPERTY UNDER FUTURE-USE CONDITIONS

In the absence of institutional controls limiting access of future uses of the Olympia Nominee Trust Co. property, there are additional exposure pathways that must be evaluated. It is possible that in the future, the currently unused land will be developed. Future land use involving excavations for utilities or construction would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short term compared with the exposure scenario developed for teenagers or young adults under current-use conditions. Therefore, this scenario will not be quantified.

It is also possible that in the future, this property will be developed for residential purposes. Should this occur, the potential exists for residents living on the property to be exposed to contaminated soils during outdoor activities. Exposure is assumed to occur via direct contact with contaminated soils with subsequent ingestion and dermal absorption of chemicals. Because these exposures are assumed to occur over a lifetime, time-weighted averages for the amount of soil ingested per exposure event, the dermal soil contact rate, and an individual's body weight were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime. The soil concentrations summarized in Table 4-4 would also apply here. These concentrations will provide a somewhat conservative approach since the concentrations of 4,4'-DDT and the carcinogenic PAHs may decrease with time due to volatilization, migration into the groundwater, or biodegradation processes.

A drinking well could be installed at the Olympia Nominee Trust property in the future. Thus, another exposure scenario would involve the ingestion of groundwater. Table 4-5 summarizes the groundwater concentrations used in this analysis. The inorganic chemicals of potential concern at the Olympia Nominee Trust Co. property do not volatilize from water and are not readily absorbed through the skin. Since this water could be used in a residential setting, exposures via inhalation and dermal contact from bathing or showering, washing clothes, cooking, washing dishes, and any other household activities which involve the use of water, the level of exposure from these activities will be evaluated only for the organic chemicals of concern. In this endangerment assessment, exposure to groundwater via ingestion will be quantified for both the inorganic and organic chemicals of concern.

The groundwater concentrations of the chemicals of potential concern summarized in Table 4-5 were sued to estimate the concentration that might be expected to occur while showering. Using a theoretical exposure model, outlined in Appendix C, Section C.2 (Foster and Chrostowski 1986, 1987), the transfer of volatile organic compounds from shower droplets into the air and their subsequent inhalation were estimated. Based on this exposure model, the potential inhalation exposures to the groundwater contaminants which could volatilize were quantified. The model estimates the intake level (in mg/kg/day), rather than the ambient air concentrations that might be expected while showering. These values are presented in Table 4-6 for the geometric mean and maximum concentrations of the contaminants in groundwater.

TABLE 4-5

GROUNDWATER CONCENTRATIONS OF THE CHEMICALS OF POTENTIAL CONCERN
FOR THE OLYMPIA NOMINEE TRUST PROPERTY

	CONCENTRATION (ug/liter)	
COMPOUND	GEOMETRIC MEAN	MAXIMUM
Arsenic	9.9	16.4
Bis(2-ethylhexyl) phthalate	6.20	14.0
1,1-Dichloroethane	2.61	6.00
<u>trans</u>-1,2-Dichloroethene	2.81	23.0
Manganese	1370	4170
Tetrachloroethene	6.10	45.0
Trichloroethene	20.9	3400
Total Xylenes	4.88	170

TABLE 4-6

INTAKE OF THE CHEMICALS OF POTENTIAL CONCERN RELEASED TO THE AIR WHILE SHOWERING WITH GROUNDWATER FROM THE OLYMPIA NOMINEE TRUST PROPERTY

	INTAKE (mg/kg/d)	
COMPOUND	GEOMETRIC MEAN	MAXIMUM
Bis(2-ethylhexyl)phthalate	2.08×10^{-7}	4.69×10^{-7}
1,1-Dichloroethane	7.22×10^{-5}	1.66×10^{-4}
trans-1,2-Dichloroethene	7.86×10^{-5}	6.44×10^{-4}
Tetrachloroethene	1.42×10^{-4}	1.05×10^{-3}
Trichloroethene	5.26×10^{-4}	8.55×10^{-2}
Total Xylenes	1.32×10^{-4}	4.61×10^{-3}

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

4.3 RISK ASSESSMENT

According to guidelines for preparing risk assessments as part of the RI/FS process (EPA 1986a), the potential adverse effects on human health should first be assessed where possible by comparing chemical concentrations found in environmental media at or near the site with applicable or relevant and appropriate requirements (ARARs) or other guidance that has been developed for the protection of human health or the environment. If ARARs are not available for all chemicals and exposures considered, quantitative risk estimates must be developed in addition to the comparison to ARARs. This section will present a comparison of exposure point concentrations to the applicable or relevant and appropriate requirements (ARARs) as well as a quantitative risk assessment.

4.3.1 COMPARISON TO APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER GUIDANCE LEVELS

In this section, the concentrations of chemicals of potential concern at the Olympia Nominee Trust Co. property are compared to ARARs. ARARs are available for groundwater but are not available for soil. Section 1.4.2 presents background information on ARARs.

Table 4-7 presents a comparison of the groundwater concentrations detected at the Olympia Nominee Trust Co. property and Federal and Commonwealth of Massachusetts drinking water standards or criteria. As can be seen from this table, some of the ARARs are exceeded. The geometric mean and maximum concentrations of arsenic did not exceed its MCL. The geometric mean and maximum concentrations of trichloroethene exceed its MCL. The maximum concentration of 1,2-dichloroethane exceeds its MCL. The geometric mean and maximum concentrations of manganese exceeds its secondary MCL; it should be noted that this standard is not federally enforceable as it is based on aesthetic considerations rather than health concerns.

The geometric mean and maximum concentrations of tetrachloroethene exceed its Massachusetts drinking water standard. The geometric mean and maximum

TABLE 4-7

COMPARISON OF CHEMICALS OF POTENTIAL CONCERN IN THE GROUNDWATER
AT THE OLYMPIA NOMINEE TRUST PROPERTY WITH ARARS AND OTHER GUIDANCE LEVELS

(mg/liter)

Compound	Concentration		ARAR	Massachusetts Drinking Water Standard
	Geometric Mean	Maximum	MCL	
Arsenic	0.0099	0.0164	0.05	0.05
Bis(2-ethylhexyl)phthalate	0.0062	0.014	--	21 (c)
1,2-Dichloroethane	0.00261	0.006	0.005	0.005
trans-1,2-Dichloroethene	0.00281	0.023	--	0.07 (a,c)
Manganese	1.37	4.17	0.05 (b)	0.05 (b)
Tetrachloroethene	0.0061	0.045	--	0.005
Trichloroethene	0.0209	3.4	0.005	0.005
Xylene	0.00488	0.17	--	0.62

(a) Proposed.

(b) Based on organoleptic considerations.

(c) Shall not exceed health advisories which have been adopted by the Massachusetts Division of Water Pollution Control and/or the EPA. For groundwater, this would equate to the Clean Water Act criteria for human health (drinking water only) or the Safe Drinking Water Act Maximum Concentration Limit Goals, whichever is more stringent.

concentrations of bis(2-ethylhexyl)phthalate, trans-1,2-dichloroethene, and xylene are below their Massachusetts drinking water standards.

4.3.2 QUANTITATIVE RISK CHARACTERIZATION

To quantitatively assess the risks to human health associated with the future-use exposure scenarios considered in this assessment, the concentrations of chemicals in relevant environmental media (exposure point concentrations) presented in Section 4.2 are converted to chronic daily intakes (CDIs). CDIs are the amount of a substance taken into the body per unit body weight per unit time, expressed in units of mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA 1986b) and over the exposure period for noncarcinogens (EPA 1986c). Section 1.4.3 summarized the methodology that will be used in this section.

In this section of the risk assessment, the intakes of chemicals of potential concern by potentially exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions, such as frequency and duration of exposure. For each exposure scenario evaluated, two exposure cases--an average case and a plausible maximum case--are considered. For the average exposure case, geometric mean concentrations are used together with what are considered to be the most likely (although conservative) exposure conditions. For the plausible maximum case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the plausible maximum case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

Chronic daily intakes, excess lifetime cancer risks, and CDI:RfD ratios for the site-related chemicals considered in this assessment, as well as the assumptions and procedures used to calculate these values, are shown below for each scenario evaluated.

4.3.2.1 Property Under Current-Use Conditions

In this section, exposure point concentrations are used to estimate the extent of human exposure to the chemicals of potential concern under the current use conditions at the Olympia Nominee Trust Co. property. As has been discussed in Section 4.2, direct contact with contaminated soils by workers, direct contact with contaminated soil and inhalation of dust generated by young adults riding dirt bikes are the exposure pathways that may have a potential impact on human health under current use conditions.

Direct Contact With Contaminated Soil. Under current-use conditions, workers from across the Aberjona River or young adults trespassing on the Olympia Nominee Trust Co. property could be exposed to contaminated soils. Direct contact with the contaminated soil could lead to dermal contact and absorption of contaminants through the skin, as well as inadvertent ingestion of the compounds.

Table 4-8 presents the assumptions used in assessing exposure via these pathways. These assumptions were based on the exposure pathway analysis presented in Section 4.2 and the best currently available information. EPA standard assumptions for average lifetime (70 years), adult body weight (70 kg), and young adult body weight (45 kg) were used (EPA 1985c).

Average and plausible maximum incidental ingestion rates for the young adults are 50 and 100 mg/day. The derivation of these rates is discussed in Appendix C, and was based primarily on the work of Lagoy (1987).

Values of 400 mg/day and 990 mg/day are used as the average and plausible maximum estimates of soil contact rates for dermal exposure. These values are contact rates for each exposure event and are based on a consideration of contact rates in mg soil/cm^2 skin (0.5-1.5 mg/cm^2) from Schaum (1984), surface area of parts of the body that are likely to be in contact with soil (e.g., approximately 84 cm^2 for the palms of the hands and 1,140 cm^2 for the forearms) from Anderson et al. (1985), and of certain subjective factors.

TABLE 4-8

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT BY YOUNG ADULTS WITH SOIL AT THE OLYMPIA NOMINEE TRUST COMPANY PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
General		
Frequency of Exposure	100 d/yr	168 d/yr
Average Lifetime	70 yr	70 yr
Incidental Ingestion Rate	50 mg/d	100 mg/d
Percent PAHs, Pesticides Absorbed from Ingested Soils	15%	45%
Percent Inorganics Absorbed from Ingested Soils	100%	100%
Soil Contact Rate	400 mg/day	990 mg/day
Percent PAHs, Pesticides Absorbed Dermally from Skin	0.3%	3%
Percent Inorganics Absorbed Dermally from Skin	Negligible	Negligible
Adults		
Duration of Exposure	10 yr	20 yr
Average Body Weight	70 kg	70 kg
Young Adult		
Duration of Exposure	6 yr	6 yr
Average Body Weight	45 kg	45 kg

These are reasonable values, but they are a source of uncertainty in the risk calculation.

The derivation of the absorption factors are summarized in Appendix C, Section C.3. These factors are based upon the likelihood that the chemicals will be adsorbed onto the soil (e.g., pesticides and PAHs) and hence, be less bioavailable than these same chemicals in drinking water, for example.

Using these assumptions, chronic daily intake (CDI) estimates for incidental soil ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Appendix C, Section C.3 of this endangerment assessment. The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption. Table 4-9 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with these exposures for worker exposure.

The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are 5×10^{-10} (i.e., five in ten billion) for the average exposure case and 3×10^{-6} (i.e., three in one million) for the plausible maximum exposure case. Exposure to chemicals which can result in noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are less than one.

The CDIs associated with direct contact with soils by young adults and the corresponding risks are presented in Table 4-10. The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are 2×10^{-9} (i.e., two in one billion) for the average exposure case and 3×10^{-6} (i.e., three in one million) for the plausible maximum exposure case. Exposure to chemicals which can result in noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are less than one.

TABLE 4-9

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY INDUSTRIAL WORKERS AT THE OLYMPIA NOMINEE TRUST PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE 70 kg ADULT, PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
4,4'-DDT	2.95E-02	3.66E-01	2.97E-11	1.84E-08	9.50E-12	1.22E-08	3.92E-11	3.06E-08	3.40E-01	1.3E-11	1.0E-08
cPAHs (a)	3.13E-02	3.41E+00	3.15E-11	1.72E-07	1.01E-11	1.13E-07	4.16E-11	2.85E-07	1.15E+01	4.8E-10	3.3E-06
TOTAL										5E-10	3E-06

B. POTENTIAL NONCARCINOGENIC RISKS (b)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE (CDI), 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Chromium	2.03E+01	9.24E+02	9.53E-07	3.62E-04	NQ	NQ	9.53E-07	3.62E-04	5.00E-03	1.91E-04	7.23E-02
4,4'-DDT	2.95E-02	3.66E-01	2.08E-10	6.45E-08	6.65E-11	4.25E-08	2.74E-10	1.07E-07	5.00E-04	5.49E-07	2.14E-04
Lead	2.38E+01	4.24E+02	1.12E-06	1.66E-04	NQ	NQ	1.12E-06	1.66E-04	6.00E-04	1.86E-03	2.77E-01
nPAHs (c)	1.69E-02	2.62E+00	1.19E-10	4.61E-07	3.81E-11	3.05E-07	1.57E-10	7.66E-07	4.10E-01	3.83E-10	1.87E-06
HAZARD INDEX										<1 (0.002)	<1 (0.3)

(a) Carcinogenic polynuclear aromatic hydrocarbons.

(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

NQ = Not quantified; dermal absorption of inorganics is negligible.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 4-10

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY YOUNG ADULTS TRESPASSING AT THE OLYMPIA NOMINEE TRUST PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE 45 kg YOUNG ADULT, PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
4,4'-DDT	2.95E-02	3.66E-01	1.15E-10	1.44E-08	1.85E-11	9.53E-09	1.34E-10	2.40E-08	3.40E-01	4.6E-11	8.1E-09
cPAHs (a)	3.13E-02	3.41E+00	1.23E-10	1.35E-07	1.96E-11	8.88E-08	1.42E-10	2.23E-07	1.15E+01	1.6E-09	2.6E-06
TOTAL										2E-09	3E-06

B. POTENTIAL NONCARCINOGENIC RISKS (b)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE (CDI), 45 kg YOUNG ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Chromium	2.03E+01	9.24E+02	6.18E-06	9.45E-04	NQ	NQ	6.18E-06	9.45E-04	5.00E-03	1.24E-03	1.89E-01
4,4'-DDT	2.95E-02	3.66E-01	1.35E-09	1.68E-07	2.16E-10	1.11E-07	1.56E-09	2.80E-07	5.00E-04	3.13E-06	5.59E-04
Lead	2.38E+01	4.24E+02	7.25E-06	4.34E-04	NQ	NQ	7.25E-06	4.34E-04	6.00E-04	1.21E-02	7.23E-01
nPAHs (c)	1.69E-02	2.62E+00	7.72E-10	1.21E-06	1.23E-10	7.96E-07	8.95E-10	2.00E-06	4.10E-01	2.18E-09	4.88E-06
HAZARD INDEX										<1 (0.01)	<1 (0.9)

(a) Carcinogenic polynuclear aromatic hydrocarbons.

(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

NQ = Not quantified; dermal absorption of inorganics is negligible.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

Inhalation of Contaminated Air. Young adults who use the Olympia Nominee Trust Co. property for recreational uses can be exposed via inhalation to contaminated air. Exposure to air contaminants may occur through inhalation of chemicals volatilized from soil or through inhalation of vehicle-generated dust. Only the latter pathway will be analyzed here due to the relatively low volatility and limited areal extent of contamination of 4,4'-DDT and the carcinogenic PAHs. The approaches used to derive the air concentrations are summarized in Appendix C. The estimated air concentrations presented in Table 4-4 are used to derive exposure intake estimates and subsequently risk.

Table 4-11 presents the assumptions used in assessing inhalation exposure. These exposures were based on EPA standard assumptions for body weight, inhalation rates and average lifetime. In addition, the exposure assumptions for frequency of occurrence derived for the direct contact with soil pathway were used.

The chronic daily intakes (CDIs) of inhaled airborne contaminants by young adults were derived using the assumed frequencies and durations listed in Table 4-11, a respiration rate of 2.8 m^3/hr (based on moderate activity rate reported by EPA (1987a)) and a body weight of 45 kg. In the absence of definitive toxicokinetic data, 100% absorption of inhaled contaminants was conservatively assumed. For chemicals considered to be potentially carcinogenic by inhalation, the total cumulative exposure of 6 years was prorated over a 70 year lifetime to derive an average daily intake in mg/kg/day. For chemicals which may cause noncarcinogenic effects by inhalation, the average daily exposure over 6 years was calculated.

Table 4-12 presents the average and plausible maximum CDIs for the young adults exposed to contaminated air associated with the Olympia Nominee Trust Co. property. The risks associated with these exposure levels are also presented. The upper bound lifetime cancer risk under this scenario is 3×10^{-8} (i.e., three in one hundred million) for the average case and 5×10^{-6} (i.e., five in one million) for the plausible maximum case. The hazard index is less than one for both the average and the plausible maximum cases.

TABLE 4-11

ASSUMPTIONS FOR USE IN THE RISK ASSESSMENT FOR INHALATION OF CONTAMINATED AIR AT THE OLYMPIA NOMINEE TRUST COMPANY PROPERTY

Parameter	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 days/year	168 days/year
Duration of Exposure	6 years	6 years
Inhalation Rate	2.8 m^3/hr	2.8 m^3/hr
Length of Exposure	1 hour	2 hours
Average Weight Over Period of Exposure	45 kg	45 kg
Average Lifetime	70 years	70 years

TABLE 4-12

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF DUST GENERATED FROM SURFACE SOILS BY YOUNG ADULTS TRESPASSING AT THE OLYMPIA NOMINEE TRUST PROPERTY

A. POTENTIAL CARCINOGENIC RISK

COMPOUND	SOIL CONCENTRATION (mg/kg) GEOMETRIC MEAN	SOIL CONCENTRATION (mg/kg) MAXIMUM	AIR CONCENTRATION (mg/m3) GEOMETRIC MEAN	AIR CONCENTRATION (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE 45 kg YOUNG ADULT, PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE 45 kg YOUNG ADULT, PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Chromium	2.03E+01	9.24E+02	5.72E-07	2.60E-05	8.36E-10	1.28E-07	4.10E+01	3.4E-08	5.2E-06
4,4'-DDT	2.95E-02	3.66E-01	8.31E-10	1.03E-08	1.21E-12	5.06E-11	3.40E-01	4.1E-13	1.7E-11
cPAHs (a)	3.13E-02	3.41E+00	8.82E-10	9.61E-08	1.29E-12	4.72E-10	6.11E+00	7.9E-12	2.9E-09
TOTAL								3E-08	5E-06

B. POTENTIAL NONCARCINOGENIC RISK (b)

COMPOUND	SOIL CONCENTRATION (mg/kg) GEOMETRIC MEAN	SOIL CONCENTRATION (mg/kg) MAXIMUM	AIR CONCENTRATION (mg/m3) GEOMETRIC MEAN	AIR CONCENTRATION (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (CDI), 45 kg YOUNG ADULT (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI), 45 kg YOUNG ADULT (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
4,4'-DDT	2.95E-02	3.66E-01	8.31E-10	1.03E-08	1.42E-11	5.91E-10	5.00E-04	2.8E-08	1.2E-06
Lead	2.38E+01	4.24E+02	6.70E-07	1.19E-05	1.14E-08	6.84E-07	6.00E-04	1.9E-05	1.1E-03
nPAHs (c)	1.69E-02	2.62E+00	4.76E-10	7.38E-08	8.12E-12	4.23E-09	4.10E-01	2.0E-11	1.0E-08
HAZARD INDEX								<1 (0.00002)	<1 (0.001)

(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

4.3.2.2 Property Under Future-Use Conditions

In the absence of institutional controls limiting access of future uses of the Olympia Nominee Trust Co. property, there are additional exposure pathways that must be evaluated. It is possible that in the future, construction activities or excavations for utilities would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short term compared with the scenario developed in Section 4.3.2.1 for young adults using the property for recreational purposes or the scenario developed below for future residents, and thus this short term exposure scenario will not be quantified.

Direct contact with contaminated soil - future residents. If the Olympia Nominee Trust property were redeveloped for residential purposes, the potential exists for residents living on the property to be exposed to contaminated soils during outdoor activities. Table 4-13 summarizes the average and plausible maximum exposure assumptions used in this evaluation. These assumptions are derived from the same sources as mentioned above for the current-use direct contact scenario, but differ in that they are average lifetime exposures. Time-weighted averages for the amount of soil ingested per exposure event, the dermal soil contact rate, and an individual's body weight were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime.

Using these assumptions, chronic daily intake (CDI) estimates for incidental soil ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Appendix C of this endangerment assessment. The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption. Table 4-14 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with these exposures.

TABLE 4-13

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT BY FUTURE RESIDENTS WITH SOIL AT THE OLYMPIA NOMINEE TRUST COMPANY PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 d/yr	168 d/yr
Duration of Exposure	70 yr	70 yr
Average Weight[a]	70 kg	70 kg
Incidental Ingestion Rate[a]	54 mg/d	145 mg/d
Percent Phthalates, Pesticides Absorbed from Ingested Soils	15%	45%
Percent Other Organic Compounds Absorbed from Ingested Soils	100%	100%
Percent Inorganic Compounds Absorbed from Ingested Soils	100%	100%
Soil Contact Rate[a]	0.79 g/d	5.4 g/d
Percent PAHs, Phthalates, Pesticides Absorbed Dermally from Skin	0.3%	3%
Percent Other Organic Compounds Absorbed Dermally from Skin	1%	10%
Percent Inorganic Compounds Absorbed Dermally from Skin	Negligible	Negligible
Average Lifetime	70 years	70 years

[a] Based on lifetime averages.

TABLE 4-14

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY FUTURE RESIDENTS AT THE OLYMPIA NOMINEE TRUST PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg) GEOMETRIC MEAN	SOIL CONCENTRATION (mg/kg) MAXIMUM	QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d) AVERAGE	QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d) PLAUSIBLE MAXIMUM	QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d) AVERAGE	QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
4,4'-DDT	2.95E-02	3.66E-01	9.35E-10	1.57E-07	2.74E-10	3.90E-07	1.21E-09	5.47E-07	3.40E-01	4.1E-10	1.9E-07
cPAHs (a)	3.13E-02	3.41E+00	9.92E-10	1.46E-06	2.90E-10	3.63E-06	1.28E-09	5.10E-06	1.15E+01	1.5E-08	5.9E-05
TOTAL										2E-08	6E-05

B. POTENTIAL NONCARCINOGENIC RISKS (b)

COMPOUND	SOIL CONCENTRATION (mg/kg) GEOMETRIC MEAN	SOIL CONCENTRATION (mg/kg) MAXIMUM	QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d) AVERAGE	QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d) PLAUSIBLE MAXIMUM	QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d) AVERAGE	QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Chromium	2.03E+01	9.24E+02	4.29E-06	8.81E-04	NQ	NQ	4.29E-06	8.81E-04	5.00E-03	8.58E-04	1.76E-01
4,4'-DDT	2.95E-02	3.66E-01	9.35E-10	1.57E-07	2.74E-10	3.90E-07	1.21E-09	5.47E-07	5.00E-04	2.42E-06	1.09E-03
Lead	2.38E+01	4.24E+02	5.03E-06	4.04E-04	NQ	NQ	5.03E-06	4.04E-04	6.00E-04	8.38E-03	6.74E-01
nPAHs (c)	1.69E-02	2.62E+00	5.36E-10	1.12E-06	1.57E-10	2.79E-06	6.93E-10	3.91E-06	4.10E-01	1.69E-09	9.55E-06
HAZARD INDEX										<1 (0.009)	<1 (0.8)

(a) Carcinogenic polynuclear aromatic hydrocarbons.

(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

NQ = Not quantified; dermal absorption of inorganics is negligible.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are $2x10^{-8}$ (i.e., two in one hundred million) for the average exposure case and $6x10^{-5}$ (i.e., six in one hundred thousand) for the plausible maximum exposure case. Under the conditions of both the average and plausible maximum cases, exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability since the hazard indices are less than one.

Ingestion of Groundwater. Under this future-use scenario, it is assumed that there are no future remedial actions and institutional actions limiting access to the use of the groundwater. Hence, individuals could be exposed to groundwater contaminants by direct ingestion of tap water. The average individual is assumed to weigh 70 kg and drink 2 liters of water each day for 70 years (an average lifetime). Based on these assumptions, and the existing chemical concentrations in the groundwater, chronic daily intakes were derived and are presented in Table 4-15. The risks associated with these intake levels are also presented for chemicals exhibiting potentially carcinogenic and noncarcinogenic effects.

The upper bound lifetime excess cancer risks associated with ingestion of groundwater are $4x10^{-4}$ (i.e., four in ten thousand) and $1x10^{-3}$ (i.e., one in one thousand) for the average and plausible maximum cases, respectively. The hazard index for the average and plausible maximum exposure scenarios are less than one. Thus, there appears to be a low probability of adverse health effects.

Inhalation of contaminants while showering. In addition to ingestion of groundwater, inhalation of volatilized contaminants can occur while using the water for nonconsumptive uses. The inorganic chemicals of potential concern for the groundwater are not expected to volatilize. As a result, arsenic and manganese were not evaluated for this exposure scenario.

Exposure to individuals while showering is quantified here. The shower model (Foster and Chrostowski 1987) discussed in Appendix C, Section C.2, was used to quantify exposure via this pathway. The potential health risks associated

TABLE 4-15

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER AT OLYMPIA NOMINEE TRUST PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Arsenic	9.9	16.4	2.83E-04	4.69E-04	1.50E+00	4.2E-04	7.0E-04
Bis(2-ethylhexyl)phthalate	6.2	14	1.77E-04	4.00E-04	8.40E-03	1.5E-06	3.4E-06
1,1-Dichloroethane	2.6	6	7.43E-05	1.71E-04	9.10E-02	6.8E-06	1.6E-05
Tetrachloroethene	6.1	45	1.74E-04	1.29E-03	5.10E-02	8.9E-06	6.6E-05
Trichloroethene	20.9	3400	5.97E-04	9.71E-02	4.60E-03	2.7E-06	4.5E-04
TOTAL	--	--	--	--	--	4E-04	1E-03

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Bis(2-ethylexthyl)phthalate	6.2	14	1.77E-04	4.00E-04	2.00E-02	8.9E-03	2.0E-02
1,1-Dichloroethane	2.6	6	7.43E-05	1.71E-04	1.20E-01	6.2E-04	1.4E-03
trans-1,2-Dichloroethene	2.8	23	8.00E-05	6.57E-04	1.00E-02	8.0E-03	6.6E-02
Manganese	1370	4170	3.91E-02	1.19E-01	2.20E-01	1.8E-01	5.4E-01
Tetrachloroethene	6.1	45	1.74E-04	1.29E-03	2.00E-02	8.7E-03	6.4E-02
Xylene (total)	4.9	170	1.40E-04	4.86E-03	2.00E+00	7.0E-05	2.4E-03
HAZARD INDEX	--	--	--	--	--	<1 (0.2)	<1 (0.7)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

with the estimated inhalation exposures while showering are presented in Table 4-16. It should be noted that while the chronic daily intake for exposure to volatile organic contaminants in groundwater via ingestion and inhalation are comparable, as expected found in the literature (Foster and Chrostowski 1987, McKone 1987, EPA 1984i), the risks from this exposure will vary due to differences in the potency factors.

The excess lifetime upper bound cancer risks associated with the average and plausible maximum cases were $9x10^{-6}$ (i.e., nine in one million) and $4x10^{-4}$ (i.e., four in ten thousand), respectively. For chemicals exhibiting noncarcinogenic effects, the individual CDI:RfD ratios were less than one resulting in hazard indices less than one for both the average and plausible maximum cases. Thus there appears to be a low probability of adverse health effects for this pathway.

4.3.3 MULTIMEDIA EXPOSURES

Exposure via one of the pathways discussed above for either the current- or future-use scenarios does not preclude exposures via other pathways. For example, the young adults using the Olympia Nominee Trust Co. property are probably exposed to both contaminated soil via direct contact and inhalation of dust generated while riding dirt bikes. The inhalation exposure however, results in a much smaller risk than the direct contact scenario. Hence, the direct contact with soil scenario dominates the exposure and risk calculations. By adding exposures from both routes would not result in any change in the overall risk calculated for the direct contact scenario alone. Therefore, in this situation, the quantitative risk is determined by only one type of exposure. Similar results are found in comparing exposure to future residents where the exposure and risk calculations are dominated by the ingestion of groundwater scenario.

4.4 <u>SUMMARY OF OLYMPIA NOMINEE TRUST COMPANY PROPERTY EVALUATION</u>

This section of the Endangerment Assessment for the Olympia Nominee Trust Company property is a baseline assessment, which evaluates potential impacts

TABLE 4-16

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VAPORS WHILE SHOWERING WITH GROUNDWATER AT OLYMPIA NOMINEE TRUST PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

	CHRONIC DAILY INTAKE (mg/kg/d)			LIFETIME UPPER BOUND EXCESS CANCER RISK	
COMPOUND	AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexy)phthalate	2.08E-07	4.69E-07	8.40E-03	1.7E-09	3.9E-09
1,1-Dichloroethane	7.19E-05	1.66E-04	9.10E-02	6.5E-06	1.5E-05
Tetrachloroethene	1.42E-04	1.05E-03	3.30E-03	4.7E-07	3.5E-06
Trichloroethene	5.25E-04	8.55E-02	4.60E-03	2.4E-06	3.9E-04
TOTAL	--	--	--	9E-06	4E-04

B. NONCARCINOGENIC EFFECTS (a)

	CHRONIC DAILY INTAKE (CDI) (mg/kg/d)			RATIO OF CDI:RfD	
COMPOUND	AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexy)phthalate	2.08E-07	4.69E-07	2.00E-02	1.0E-05	2.3E-05
1,1-Dichloroethane	7.19E-05	1.66E-04	1.20E-01	6.0E-04	1.4E-03
trans-1,2-Dichloroethene	7.83E-05	6.44E-04	1.00E-02	7.8E-03	6.4E-02
Tetrachloroethene	1.42E-04	1.05E-03	2.00E-02	7.1E-03	5.2E-02
Xylenes (total)	1.33E-04	4.61E-03	1.00E-02	1.3E-02	4.6E-01
HAZARD INDEX	--	--	--	<1 (0.02)	<1 (0.06)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

to human health in the absence of further remedial actions under both current- and future-use scenarios. Chemicals of potential concern were selected based on the analytical sampling data of the environmental media and consideration of toxicity. The soil chemicals of potential concern were chromium, 4,4'-DDT, lead, and the carcinogenic and noncarcinogenic PAHs. The groundwater chemicals of potential concern were arsenic, bis(2-ethylhexyl) phthalate, 1,1-dichloroethane, trans-1,2-dichloroethene, manganese, tetrachloroethene, trichloroethene, and total xylenes.

Under current land-use conditions at the Olympia Nominee Trust Company property, the principal exposure pathways by which human receptors could potentially be exposed to site contaminants originated with the contaminated soils. Young adults were assumed to use the property for recreational purposes. Exposure scenarios were developed for direct contact with soil which included dermal contact with and incidental absorption of soil and for the inhalation of dust generated while riding dirt bikes. Average and plausible maximum exposure scenarios were developed for this pathway. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed population. Human health risks were assessed based on these estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of workers to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $5x10^{-10}$ for the average exposure case and $3x10^{-6}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of young adults to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $2x10^{-9}$ for the average exposure case and $3x10^{-6}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are less than one and equal to one, respectively.

- Exposure of young adults through the inhalation of dust generated while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of 3×10^{-8} and 5×10^{-6} for the average and plausible maximum exposure cases, respectively. There appears to be a low probability of adverse health effects resulting from noncarcinogenic exposure since the hazard indices are less than one and equal to one for the average and plausible maximum exposure cases.

The exposure scenario described above would apply for future land-use conditions as well. In addition, exposure pathways related to residential soil exposure and to ingestion of the groundwater were considered. Average and plausible maximum exposure scenarios were developed. The conclusions are as follows:

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of 2×10^{-8} for the average exposure case and 6×10^{-5} for the plausible maximum exposure case. Under the conditions of both the average and plausible maximum cases, there appears to be a low probability of adverse health effects as the hazard indices are below one.

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of 4×10^{-4} and 1×10^{-3} for the average and plausible maximum cases, respectively. The hazard index is below one for both the average case and the plausible maximum case. Thus, there appears to be a low probability of adverse health effects.

- Inhalation of volatiles released from the groundwater while showering could result in 9×10^{-6} and 4×10^{-4} potential upper bound excess lifetime cancer risks for average and plausible maximum cases, respectively. The hazard index was less than 1 for both the average and plausible maximum cases.

5.0 UNIFIRST CORPORATION

The Unifirst Corporation is a uniform cleaning service company that used tetrachloroethylene (PCE) in its dry cleaning operations. During the period of 1966 to 1968, the company used five to six 55-gallon drums of PCE per year in their operations. From 1977 to 1982, PCE was stored above ground in a 5,000 gallon tank for transfer to tank trucks and distribution to other facilities.

5.1 CHEMICALS OF POTENTIAL CONCERN

The basis for the selection of the chemicals of potential concern is outlined in Appendix A of this document and is based upon the methodology presented in the Superfund Public Health Evaluation Manual (EPA 1986a). The data used in this evaluation resulted from site investigations conducted by NUS for U.S. EPA (NUS 1986, Alliance 1986), the supplemental RI conducted by Ebasco for USEPA (Ebasco 1988a), by ERT for Unifirst Corporation, and by EPA. In cases where duplicate analyses were performed, the validated U.S. EPA data were used.

5.1.1 SOIL

The Unifirst Corporation property has been paved with asphalt. The available soil data, summarized in Table 5-1, were collected during well installation. Only data on volatile organic compounds are available. It is likely that the presence of these compounds in the soil samples is due to their presence in the groundwater. Acetone and methylene chloride are not selected as chemicals of potential concern due to their presence in blanks associated with these samples. Tetrachloroethene (PCE) is the primary chemical associated with this site and is selected as a chemical of concern. 1,1,1-Trichloroethane, the other chlorinated solvent, was not selected as a chemical of potential concern due to the low concentration detected at the site. There is insufficient toxicity information on ethyl ether (1,1-oxybisethane) and hexane and as a result, these chemicals were not selected as chemicals of potential concern.

TABLE 5-1

COMPOUNDS DETECTED IN SOIL AT THE UNIFIRST CORPORATION PROPERTY OF WELLS G & H SITE

COMPOUND	SURFACE SOIL			SUBSURFACE SOIL		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/kg)						
ACETONE	4/4	36.4	170	8/8	50.8	105
ETHANE, 1,1-OXYBIS	NR			1/1	NA	10.0
HEXANE	2/2	1.83	2.80	6/6	2.50	16.0
METHYLENE CHLORIDE	2/2	9.62	13.2	3/3	5.90	7.00
TETRACHLOROETHENE	3/3	47.0	170	2/7	31.2	290
TOLUENE	1/1	NA	6.00	ND		
1,1,1-TRICHLOROETHANE	1/1	NA	12.0	ND		
1,1,2-TRICHLORO-1,2,2-TRI-FLUOROETHANE	1/1	NA	32.0	NR		

NA = Not applicable; mean not calculated with only one positive detection.
ND = Not detected.

NR = Not reported. No information was available concerning analysis for this compound in this medium. It is unknown whether the omission of the compound from the data summary indicates was not detected or not tested for.

Toluene and 1,1,2-trichloro-1,2,2-trifluoroethane were not selected as chemicals of concern since they were detected at low concentrations.

5.1.2 GROUNDWATER

The volatile organic compounds detected in the groundwater at the Unifirst Corporation property are presented in Table 5-2. The most frequently detected compounds were trans-1,2-dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, and trichloroethene. These are, therefore, selected as chemicals of potential concern. The very high concentrations of tetrachloroethene are most likely due to a tetrachloroethene spill which produced a layer of pure chemical in the bedrock. Other chlorinated organics detected include carbon tetrachloride, 1,1-dichloroethane, and 1,1-dichloroethene. Of these, carbon tetrachloride will not be selected as a chemical of potential concern since it was detected in approximately 5% of the samples. Acetone was detected in 4 of 60 samples but is not selected as a chemical of potential concern because it was detected sporadically only in one well. That is, acetone was detected in one well on one week and not the next, as seen in Appendix E. Benzene, bromoform, ethylbenzene, and total xylenes were not selected as chemicals of potential concern since they were detected in groundwater samples taken in April, 1985 but not in May or June, 1985 samples and have not been detected in other wells. Furthermore, they were also not detected in the 1987 sampling. Chrysene and naphthalene were detected at levels exceeding their solubilities. This effect may be due to a co-solubilization effect since these compounds are more soluble in tetrachloroethene than they are in water. Since the distribution of these compounds in groundwater is unknown, that is, these compounds could be found mixed in the tetrachloroethene layer rather than dissolved in the groundwater itself and due to the limited toxicity information for chrysene, they were not considered as chemicals of potential concern.

The inorganic constituents detected above background levels were aluminum, barium, iron, and manganese, as seen by comparison with levels in Table A-2, Appendix A. Very low levels (i.e., at or below background) of cadmium, calcium, cobalt, copper, lead, magnesium, mercury, nickel, potassium, silver,

TABLE 5-2

COMPOUNDS DETECTED IN GROUNDWATER AT THE UNIFIRST CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/liter)			
BENZENE	1/66	NA	1700
BROMOFORM	1/71	NA	3000
2-BUTANONE	2/48	15.2	110
CARBON TETRACHLORIDE	11/71	5.62	230
1,1-DICHLOROETHANE	16/71	17.2	810
1,1-DICHLOROETHENE	11/71	6.37	160
TRANS-1,2-DICHLOROETHENE	29/71	30.8	5000
ETHYLBENZENE	1/66	NA	7400
TETRACHLOROETHENE	63/70	640	22000
TOLUENE	22/64	14.9	380
1,1,1-TRICHLOROETHANE	27/70	29.5	3200
TRICHLOROETHENE	30/71	22.2	16000
TRICHLOROFLUOROMETHANE	1/23	NA	2.00
TOTAL XYLENES	1/66	NA	2900
SEMIVOLATILES/BASE NEUTRALS			
CHRYSENE	1/2	NA	3.30
INORGANICS (ug/liter)			
ALUMINUM	2/2	4500	7230
BARIUM	2/2	133	223
CADMIUM	1/2	NA	5.40
CALCIUM	2/2	76300	78600
COBALT	1/2	NA	6.60
COPPER	1/1	NA	46.0
IRON	2/2	11600	18200
LEAD	1/2	NA	18.0
MAGNESIUM	2/2	9410	10800
MANGANESE	2/2	309	435
MERCURY	1/2	NA	0.35
NICKEL	1/1	NA	11.0
POTASSIUM	2/2	6290	8800
SILVER	1/2	NA	4.40
SODIUM	2/2	50900	52000
TIN	1/2	NA	40.0
VANADIUM	2/2	11.5	16.0
ZINC	1/1	NA	44.0

NA = Not applicable; mean not calculated with only one positive detection.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE A GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

sodium, tin, vanadium and zinc were detected in the groundwater. Limited toxicity information is available for aluminum so it was not selected as a chemical of potential concern. In addition, the levels of aluminum detected in the groundwater suggest that either aluminum was present in the particulate phase or complexed with naturally occurring organic acids which can act to increase the solubility of aluminum in water (Hem 1985). Manganese is an essential nutrient and since it was not detected at greatly elevated levels (i.e., greater than 10 times background), it was not selected as a chemical of potential concern. Barium and iron were detected at levels approximately twice the background concentrations. Given the natural variation in samples, these compounds were also not selected as chemicals of potential concern. It should be noted that the geometric mean and maximum concentrations of sodium exceeded the Massachusetts advisory level of 20,000 ug/liter for persons on a salt restricted diet.

5.1.3 SUMMARY

The chemicals of potential concern for the Unifirst Corporation property are summarized in Table 5-3. The soil chemical of potential concern is tetrachloroethene. The groundwater chemicals of potential concern are 1,1-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, and trichloroethene.

5.2 EXPOSURE ASSESSMENT

5.2.1 PROPERTY UNDER CURRENT-USE CONDITIONS

Under current-use conditions, there are no exposure pathways that are complete. That is, while there is measurable contamination in soil and groundwater at the Unifirst Corporation property, there are currently no receptors. The Unifirst Corporation property is paved and therefore, exposure to soil is nonexistent. There are no known users of the groundwater at the Unifirst Corporation property and consequently, no exposure exists currently.

TABLE 5-3

CHEMICALS OF POTENTIAL CONCERN FOR THE UNIFIRST CORPORATION PROPERTY

SOIL	GROUNDWATER
Tetrachloroethene	1,1-Dichloroethane
	1,1-Dichloroethene
	trans-1,2-Dichloroethene
	Tetrachloroethene
	Toluene
	1,1,1-Trichloroethane
	Trichloroethene

5.2.2 PROPERTY UNDER FUTURE-USE CONDITIONS

In the absence of institutional controls limiting access of future uses of the Unifirst Corporation property, there are several exposure pathways which must be considered. It is possible that in the future, the property will be expanded. Future land use involving excavations for utilities or construction would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short term and will not be quantified. In addition, it is likely the contamination seen is from degassing of groundwater.

It is also possible that in the future, this property will be developed for residential purposes. Should this occur, the potential exists for residents living on the property to be exposed to contaminated soils during outdoor activities. Exposure is assumed to occur via direct contact with contaminated soils with subsequent ingestion and dermal absorption of chemicals. The exposure point concentrations are summarized in Table 5-4. Because these exposures are assumed to occur over a lifetime, time-weighted averages for the amount of soil ingested per exposure event, the dermal soil contact rate, and an individual's body weight were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime. The assumptions are summarized in Appendix C.

It is also possible that in the future, a well to be used for drinking water purposes will be installed at the Unifirst Corporation property. Thus, another exposure scenario would involve the ingestion of groundwater. Should this water be used in a residential setting, exposures could occur via inhalation and dermal contact from bathing or showering, washing clothes, cooking, washing dishes, and any other household activities which involve the use of water. In this endangerment assessment, exposure via ingestion and inhalation while showering will be quantified. The groundwater concentrations an individual might be exposed to are summarized in Table 5-5. The assumptions used in estimating exposures are summarized in Appendix C.

TABLE 5-4

SOIL CONCENTRATIONS FOR THE CHEMICALS OF POTENTIAL CONCERN
FOR THE UNIFIRST CORPORATION PROPERTY

COMPOUND	CONCENTRATION (ug/kg)	
	GEOMETRIC MEAN	MAXIMUM
Tetrachloroethene	47.0	170

NA = Not applicable; mean not calculated with only one positive detection.

TABLE 5-5

GROUNDWATER CONCENTRATIONS FOR THE CHEMICALS OF POTENTIAL CONCERN
FOR THE UNIFIRST CORPORATION PROPERTY

COMPOUND	CONCENTRATION (ug/liter)	
	GEOMETRIC MEAN	MAXIMUM
1,1-Dichloroethane	17.2	810
1,1-Dichloroethene	6.4	160
trans-1,2-Dichloroethene	30.8	5000
Tetrachloroethene	640	22000
Toluene	14.9	380
1,1,1-Trichloroethane	29.5	3200
Trichloroethene	22.2	16000

The groundwater concentrations of the chemicals of potential concern summarized in Table 5-5 were used to estimate the concentrations that might be expected to occur while showering. Using a theoretical exposure model, outlined in Appendix C, Section C.2, (Foster and Chrostowski 1986, 1987), the transfer of volatile organic compounds from shower droplets into the air and their subsequent inhalation were estimated. Based on this exposure model, the potential inhalation exposures to the groundwater contaminants which could volatilize were quantified. The model estimates the intake level (in mg/kg/day), rather than the ambient air concentrations that might be expected while showering. These values are presented in Table 5-6 for the geometric mean and maximum concentrations of the contaminants in groundwater.

5.3 RISK ASSESSMENT

According to guidelines for preparing risk assessments as part of the RI/FS process (EPA 1986a), the potential adverse effects on human health should first be assessed where possible by comparing chemical concentrations found in environmental media at or near the site with applicable or relevant and appropriate requirements (ARARs) or other guidance that has been developed for the protection of human health or the environment. If ARARs are not available for all chemicals and exposures considered, quantitative risk estimates must be developed in addition to the comparison to ARARs. This section will present a comparison of exposure point concentrations to the applicable or relevant and appropriate requirements (ARARs) as well as a quantitative risk assessment.

5.3.1 COMPARISON TO APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OR OTHER CRITERIA

In this section, the concentrations of chemicals of potential concern in groundwater at the Unifirst Corporation property are compared to ARARs and other available criteria. Table 5-7 presents this comparison, and as can be seen from the table, the geometric mean and maximum concentrations of trichloroethene exceed its MCL. The maximum concentrations of 1,1-dichloroethene and 1,1,1-trichloroethane exceed their respective MCL; however,

TABLE 5-6

INTAKE OF CHEMICALS OF POTENTIAL CONCERN RELEASED TO THE AIR WHILE SHOWERING WITH GROUNDWATER FROM THE UNIFIRST CORPORATION PROPERTY

	INTAKE (mg/kg/day)	
COMPOUND	GEOMETRIC MEAN	MAXIMUM
1,1-Dichloroethane	4.76×10^{-4}	2.24×10^{-2}
1,1-Dichloroethene	1.84×10^{-4}	4.60×10^{-3}
trans-1,2-Dichloroethene	8.62×10^{-4}	1.40×10^{-1}
Tetrachloroethene	1.49×10^{-2}	5.12×10^{-1}
Toluene	4.25×10^{-4}	1.08×10^{-2}
1,1,1-Trichloroethane	7.48×10^{-4}	8.11×10^{-2}
Trichloroethene	5.58×10^{-4}	4.02×10^{-1}

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 5-7

COMPARISON OF CHEMICALS OF POTENTIAL CONCERN IN THE GROUNDWATER AT THE UNIFIRST CORPORATION WITH ARARS AND OTHER GUIDANCE

(mg/liter)

Compound	Concentration		ARAR		
	Geometric Mean	Maximum	MCL	Massachusetts Drinking Water Standard	AWQC Adjusted for Drinking Water Only
1,1-Dichloroethane	0.0172	0.810	--	--	(a)
1,1-Dichloroethene	0.0064	0.16	0.007	0.007	--
trans-1,2-Dichloroethene	0.0308	5.000	--	0.07 (b,c)	--
Tetrachloroethene	0.64	22.000	--	0.005	--
Toluene	0.0149	0.038	--	2.0 (b,c)	--
1,1,1-Trichloroethane	0.0295	3.200	0.20	0.20 (c)	--
Trichloroethene	0.0222	16.000	0.005	0.005	--

-- = Not available
(a) Insufficient data.
(b) Proposed.
(c) Shall not exceed health advisories which have been adopted by the Massachusetts Division of Water Pollution Control and/or the EPA. For groundwater, this would equate to the Clean Water Act criteria for human health (drinking water only) or the Safe Drinking Water Act Maximum Concentration Limit Goals, whichever is more stringent.

their geometric mean concentrations are below their respective MCLS. The maximum concentration of trans-1,2-dichloroethene exceeds its Massachusetts drinking water standard. The geometric mean and maximum concentrations of tetrachloroethene exceed the Massachusetts drinking water standard. The geometric mean and maximum concentrations of toluene are below the Massachusetts drinking water standard. There are no ARARs or other guidance levels for 1,1-dichloroethane. There are no ARARs for soil.

5.3.2 QUANTITATIVE RISK CHARACTERIZATION

To quantitatively assess the risks to human health associated with the future-use exposure scenarios considered in this assessment, the concentrations of chemicals in relevant environmental media (exposure point concentrations) presented in Section 5.2 are converted to chronic daily intakes (CDIs). CDIs are the amount of a substance taken into the body per unit body weight per unit time, expressed in units of mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA 1986b) and over the exposure period for noncarcinogens (EPA 1986c). Section 1.4.4 summarized the methodology that will be used in this section.

In this section of the risk assessment, the intakes of chemicals of potential concern by potentially exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions such as frequency and duration of exposure. For each exposure scenario evaluated, two exposure cases--an average case and plausible maximum case--are considered. For the average exposure case, geometric mean concentrations are used together with what are considered to be the most likely (although conservative) exposure conditions. For the plausible maximum case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the plausible maximum case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

Chronic daily intakes, excess lifetime cancer risks, and CDI:RfD ratios for the site-related chemicals considered in this assessment, as well as the assumptions and procedures used to calculate these values, are shown below for each scenario evaluated.

As was discussed in Section 5.2.1, there are no pathways that are currently complete. In the absence of future remedial actions and institutional actions limiting access to the property for redevelopment, individuals could be exposed to groundwater and soil contaminants. Exposure to groundwater could involve ingestion or inhalation of volatilized contaminants while using the water for nonconsumptive uses.

5.3.2.1 Ingestion of Groundwater - Future-Use Scenario

Individuals could be exposed to groundwater contaminants by direct ingestion of tap water. The average individual is assumed to weigh 70 kg and drink 2 liters of water each day for 70 years (an average lifetime). Based on these assumptions, and the existing chemical concentrations in the groundwater, chronic daily intakes were derived and are presented in Table 5-8.

The risks associated with these intake levels are also presented for chemicals potentially exhibiting carcinogenic and noncarcinogenic effects.

The upper bound lifetime excess cancer risks associated with ingestion are $1x10^{-3}$ (i.e., one in one thousand) and $4x10^{-2}$ (i.e., four in one hundred) for the average and plausible maximum cases, respectively. The potential upper bound excess cancer risk under plausible maximum conditions may result in significant disease. The evaluation of risks is based upon a low dose exposure. Evaluation of risks at extremely high doses is beyond the scope of this project. The hazard index for the average exposure scenario is less than one indicating a low probability of adverse health effects. Under the plausible maximum exposure scenario, the hazard index exceeds one, suggesting a potential threat to human health. The non-cancer risk associated with ingestion results from exposure to trans-1,2-dichloroethene, 1,1,1-trichloroethane, and tetrachloroethene. The similarities in chemical

TABLE 5-8

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER AT UNIFIRST CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	PLAUSIBLE MAXIMUM
1,1-Dichloroethane	17.2	810	4.91E-04	2.31E-02	9.10E-02	4.5E-05	2.1E-03
1,1-Dichloroethene	6.4	160	1.83E-04	4.57E-03	6.00E-01	1.1E-04	2.7E-03
Tetrachloroethene	640	22000	1.83E-02	6.29E-01	5.10E-02	9.3E-04	3.2E-02
Trichloroethene	22.2	16000	6.34E-04	4.57E-01	1.10E-02	7.0E-06	5.0E-03
TOTAL	--	--	--	--	--	1E-03	4E-02

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	MAXIMUM	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	PLAUSIBLE MAXIMUM
1,1-Dichloroethane	17.2	810	4.91E-04	2.31E-02	1.20E-01	4.1E-03	1.9E-01
1,1-Dichloroethene	6.4	160	1.83E-04	4.57E-03	9.00E-03	2.0E-02	5.1E-01
trans-1,2-Dichloroethene	30.8	5000	8.80E-04	1.43E-01	1.00E-02	8.8E-02	1.4E+01
Tetrachloroethene	640	22000	1.83E-02	6.29E-01	2.00E-02	9.1E-01	3.1E+01
Toluene	14.9	380	4.26E-04	1.09E-02	3.00E-01	1.4E-03	3.6E-02
1,1,1-Trichloroethane	29.5	3200	8.43E-04	9.14E-02	9.00E-02	9.4E-03	1.0E+00
HAZARD INDEX	--	--	--	--	--	1	>1 (47)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number.) A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

structure, target organs, and toxicity between these chemicals indicates that their concentrations and CDI:RfD ratios should be considered additive. To determine whether or not there would be any adverse health effects from short-term exposure to the three chemicals whose maximum concentrations exceeded their RFDs, their maximum concentrations were compared to human health criteria for short-term exposures. The maximum concentration of trans-1,2-dichloroethene exceeded the 10-day health advisory of 1,430 ug/liter for children and was less than the one-day health advisory of 20,000 ug/liter for children (EPA 1987h). Both the one-day and 10-day health advisories for tetrachloroethene are 2,000 ug/liter (EPA 1987i). These concentrations were exceeded by the maximum groundwater concentration. The maximum CDI for 1,1,1-trichloroethane does not exceed its subchronic RfD of 0.9 mg/kg/d (EPA 1988e), nor does the maximum groundwater concentration exceed either the one-day (140,000 ug/liter) or the 10-day (35,000 ug/liter) health advisory for children (EPA 1987j).

5.3.2.2 Inhalation Of Contaminants While Showering - Future-Use Scenario

In addition to ingestion of groundwater, inhalation of volatilized contaminants can occur while using the water for nonconsumptive uses. Exposure to individuals while showering is quantified here. The shower model of Foster and Chrostowski (1987), discussed in Appendix C, Section C.2, was used to quantify exposure via this pathway. The potential health risks associated with the estimated inhalation exposures while showering are presented in Table 5-9. It should be noted that while the chronic daily intake for exposure to volatile organic contaminants in groundwater via ingestion and inhalation are comparable, as expected from the literature (Foster and Chrostowski 1987, McKone 1987, EPA 1984i), the risks from this exposure will vary due to differences in the potency factors.

The excess lifetime upper bound cancer risks associated with the average and plausible maximum cases were $3x10^{-4}$ (i.e., three in ten thousand) and $1x10^{-2}$ (i.e., one in one hundred), respectively. For chemicals exhibiting noncarcinogenic effects, the individual CDI:RfD ratios for each compound under average conditions were below one as was the hazard index. The CDI:RfD ratio

TABLE 5-9

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VAPORS WHILE SHOWERING WITH GROUNDWATER AT UNIFIRST CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
1,1-Dichloroethane	4.76E-04	2.24E-02	9.10E-02	4.3E-05	2.0E-03
1,1-Dichloroethene	1.84E-04	4.60E-03	1.20E+00	2.2E-04	5.5E-03
Tetrachloroethene	1.49E-02	5.12E-01	3.30E-03	4.9E-05	1.7E-03
Trichloroethene	5.58E-04	4.02E-01	4.60E-03	2.6E-06	1.8E-03
TOTAL	--	--	--	3E-04	1E-02

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
1,1-Dichloroethane	4.76E-04	2.24E-02	1.20E-01	4.0E-03	1.9E-01
1,1-Dichloroethene	1.84E-04	4.60E-03	9.00E-03	2.0E-02	5.1E-01
trans-1,2-Dichloroethene	8.62E-04	1.40E-01	1.00E-02	8.6E-02	1.4E+01
Tetrachloroethene	1.49E-02	5.12E-01	2.00E-02	7.4E-01	2.6E+01
Toluene	4.25E-04	1.08E-02	1.50E+00	2.8E-04	7.2E-03
1,1,1-Trichloroethane	7.48E-04	8.11E-02	3.00E-01	2.5E-03	2.7E-01
HAZARD INDEX	--	--	--	<1 (0.9)	>1 (41)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

exceeded one for exposure to trans-1,2-trichloroethene and tetrachloroethene under plausible maximum conditions, and hence, the hazard index exceeded one also.

5.3.2.3 Direct Contact With Contaminated Soil - Future-Use Scenario

If the Unifirst Corporation property were redeveloped for residential purposes and the pavement was torn up, the potential exists for residents living on the property to be exposed to contaminated soils during outdoor activities. Table 5-10 summarizes the average and plausible maximum exposure assumptions used in this evaluation. These assumptions are average lifetime exposures. Time-weighted averages for the amount of soil ingested per exposure event, the dermal soil contact rate, and an individual's body weight were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime.

Using these assumptions, chronic daily intake (CDI) estimates for incidental soil ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Section C.3 of Appendix C of this endangerment assessment. The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption. Table 5-11 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with these exposures.

The upper bound lifetime excess cancer risks associated with tetrachloroethene, the only soil chemical of potential concern exhibiting potential carcinogenic effects, are $8x10^{-10}$ (i.e., eight in ten billion) for the average exposure case and $4x10^{-8}$ (i.e., four in one hundred million) for the plausible maximum exposure case. Under the conditions of both the average and plausible maximum cases, exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability since the ratios of the CDI:RfD are below one.

TABLE 5-10

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT BY FUTURE RESIDENTS WITH SOIL AT THE UNIFIRST CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 d/yr	168 d/yr
Duration of Exposure	70 yr	70 yr
Average Weight	63 kg	63 kg
Incidental Ingestion Rate[a]	54 mg/d	145 mg/d
Percent Organic Compounds Absorbed from Ingested Soils	100%	100%
Percent Inorganic Compounds Absorbed from Ingested Soils	100%	100%
Soil Contact Rate[a]	0.79 g/d	5.4 g/d
Percent Organic Compounds Absorbed Dermally from Skin	1%	10%
Percent Inorganic Compounds Absorbed Dermally from Skin	Negligible	Negligible
Average Lifetime	70 years	70 years

[a] Based on lifetime averages.

TABLE 5-11

EXPOSURES AND RISKS ASSOCIATED WITH CONTACT OF SURFACE SOILS BY FUTURE RESIDENTS AT THE UNIFIRST CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Tetrachloroethene	4.70E-02	1.70E-01	9.93E-09	1.62E-07	5.26E-09	6.04E-07	1.52E-08	7.66E-07	5.10E-02	7.7E-10	3.9E-08

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Tetrachloroethene	4.70E-02	1.70E-01	9.93E-09	1.62E-07	5.26E-09	6.04E-07	1.52E-08	7.66E-07	2.00E-02	7.59E-07	3.83E-05

NA = Not applicable; geometric mean not detected with only one positive detection.
(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

5.3.3 MULTIMEDIA EXPOSURES

Exposure via one of the pathways discussed above for the future-use scenarios does not preclude exposures via other pathways. For example, residents of the area may be exposed to contaminated soil and contaminated tap water.

Exposure by one route generally dominates the exposure and risk calculations, and by adding exposures from other routes is unlikely to have a substantial effect on risks. For example, under the average future-use exposure scenario, the upper bound excess lifetime cancer risk associated with direct contact with soil is 8×10^{-10}. The upper bound lifetime cancer risk associated with the inhalation of vapors released while showering is 3×10^{-4}, and that associated with the ingestion of groundwater is 1×10^{-3}. The sum of these three values is approximately equal to the risk value associated with exposure to contaminants in groundwater. Therefore, in this situation, the quantitative risk is dominated by one exposure pathway.

5.4 SUMMARY OF UNIFIRST CORPORATION PROPERTY EVALUATION

This section of the Endangerment Assessment for the Unifirst Corporation property is a baseline assessment, which evaluates potential impacts to human health in the absence of further remedial actions under both current- and future-use scenarios. Chemicals of potential concern were selected based on the sampling data of the environmental media and consideration of toxicity. The soil chemical of potential concern was tetrachloroethene. The groundwater chemicals of potential concern were 1,1-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, and trichloroethene.

Under current land-use conditions, there are no exposure pathways by which human receptors could potentially be exposed to site contaminants. Under future-use conditions, exposure pathways related to groundwater use and soil exposure were considered. Average and plausible maximum exposure scenarios were developed for ingestion of groundwater, inhalation of volatiles while showering, and direct contact with soil which included dermal absorption from and incidental ingestion of soil. The conclusions are summarized as follows:

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of $1x10^{-3}$ and $4x10^{-2}$ for the average and plausible maximum cases, respectively. The hazard index equaled 1 for the average case but exceeded 1 for the plausible maximum case.

- Inhalation of volatiles released from the groundwater while showering could result in $3x10^{-4}$ and $1x10^{-2}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average and greater than one for the plausible maximum cases.

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of $8x10^{-10}$ for the average exposure case and $4x10^{-8}$ for the plausible maximum exposure case. Under the conditions of both the average and plausible maximum cases, the hazard indices, for exposure to chemicals exhibiting noncarcinogenic effects, are below one.

6.0 WILDWOOD CONSERVATION CORPORATION

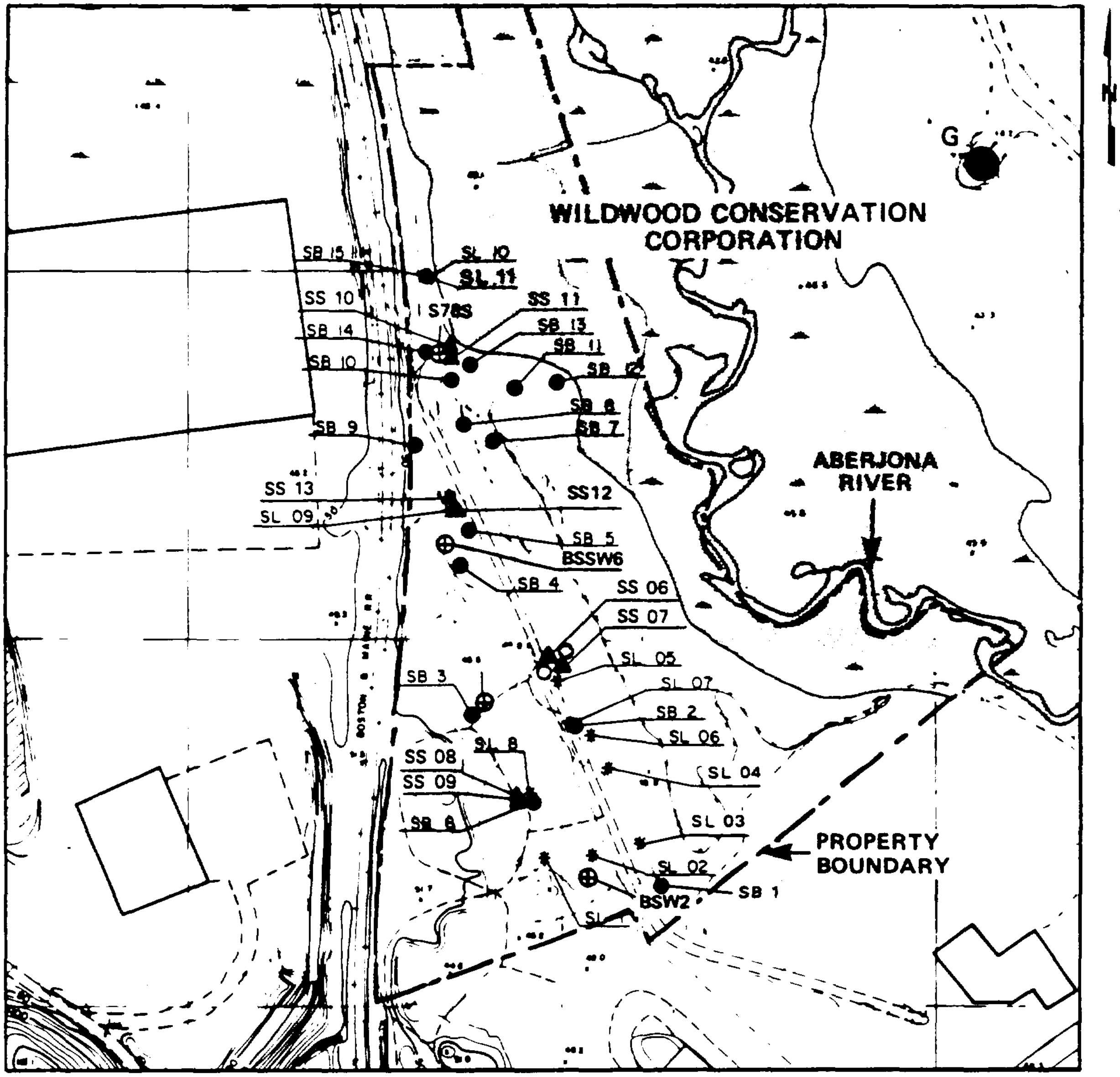
The Wildwood Conservation Corporation is the current owner of an undeveloped 15 acre parcel of land west of Wells G & H. The land is bordered by the Boston and Maine railroad to the west, the Aberjona River to the east, Olympia Nominee Trust to the north, and Whitney Barrel Company, Aberjona Autoparts Company, and Murphy Waste Oil Service Company to the south. The Wildwood site was formerly owned by the John J. Riley Company and by Beatrice Foods, Inc.

6.1 <u>CHEMICALS OF POTENTIAL CONCERN</u>

The basis for the selection of chemicals of potential concern is outlined in Appendix A of this endangerment assessment. Validated analytical sampling data collected by NUS (NUS 1986, Alliance 1986) and Ebasco (1988a), which is tabulated in Appendix E of this report, was used with the methodology presented in the Superfund Public Health Evaluation Manual (EPA 1986a) to select those chemicals which may pose a threat to human health and the environment.

6.1.1 SOIL AND SLUDGES

The soils at the Wildwood Conservation Corporation property were characterized with numerous sludge piles. These sludges ranged in consistency from a dry, cake-like asphalt looking material to an oily, petroleum looking, moist material. Some of the materials classified as sludges looked like spill materials or raw products. In a few instances, the sludges could have been discolored soils (Ebasco 1988b). Soil and sludge samples were taken from various locations on the Wildwood property, as seen in Figure 6-1. For the purposes of this evaluation, the soil samples were treated separately from the sludges. Additionally, the sludges were divided into two groups. The intention here was to determine the nature and extent of the contamination and, in the event of variable contamination, to delineate "hot spots" or areas of contamination which should be targeted for removal action.



100 0 100 200 300 FEET

- ● SB 4 – SOIL BORING LOCATION AND NUMBER
- ⊕ S78S – WELL LOCATION AND NUMBER
- ▲ SS 06 – SURFACE SOIL LOCATION AND NUMBER
- ✳ SL 09 – SLUDGE SAMPLE LOCATION AND NUMBER
- ——— — ——— PROPERTY BOUNDARY
- OO APPROXIMATE SEWER MANHOLE LOCATIONS
- □ – WETLANDS

U.S. ENVIRONMENTAL PROTECTION AGENCY

WELLS G & H

Figure 6-1

WILDWOOD PROPERTY
SOIL AND SLUDGE SAMPLE LOCATIONS

EBASCO SERVICES INCORPORATED

The surface soil data, summarized in Table 6-1, reveal widespread contamination by organic chemicals including pesticides and PCBs. The subsurface soil data are summarized in Table 6-2 and are used to confirm the presence of some of the more mobile organic compounds and will aid in the selection of chemicals of potential concern.

The most frequently detected compounds in the soil are acetone, methylene chloride, and trichloroethene. All were found in both surface and subsurface soils at about the same concentrations and hence are selected as chemicals of potential concern. Other volatile organic compounds detected more than once are 2-butanone, trans-1,2-dichloroethene, ethylbenzene, tetrachloroethene, toluene, 1,1,1-trichloroethane, and xylene. 2-Butanone was detected with about the same frequency in both surface and subsurface soils; it was not selected as a chemical of potential concern because it belongs to the same class of compounds as acetone and it was detected at concentrations much lower than acetone. 1,1,1-Trichloroethane was also not selected as a chemical of potential concern due to the relatively low concentrations detected and its relatively low toxicity compared to the chlorinated solvents. Ethylbenzene, toluene, and xylene were detected in both sets of soil samples. These three compounds have similar health endpoints in humans; toluene was detected the most frequently and in the greatest concentrations and hence was selected as a chemical of potential concern representing this group of compounds.

Numerous polynuclear aromatic hydrocarbons (PAHs) were detected at the Wildwood property. The potentially carcinogenic members of this class of compounds, as determined by the International Agency for Research on Cancer (IARC), detected at this property (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-c,d)perylene) will be treated together and evaluated as chemicals of potential concern. The toxicity categorization of the PAHs has been established by IARC (1983). There is relatively little data on PAHs which show non-carcinogenic effects. For example, napthalene is the only non-carcinogenic PAH for which EPA has derived an RfD. The noncarcinogenic PAHs will be treated as a group using the IARC classification scheme and risk will be evaluated using the RfD for naphthalene. The noncarcinogenic PAHs detected at the site are acenaphthene,

TABLE 6-1

COMPOUNDS DETECTED IN SURFACE SOILS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/kg)			
VOLATILES			
ACETONE	8/8	81.4	1200
2-BUTANONE	2/16	6.49	67.1
CHLOROFORM	1/15	NR	2.00
TRANS-1,2-DICHLOROETHENE	5/16	4.07	89.0
ETHYLBENZENE	4/16	2.97	7.94
2-HEXANONE	1/16	NA	51.0
METHYLENE CHLORIDE	11/15	22.1	670
TETRACHLOROETHENE	5/16	7.44	2000
TOLUENE	7/14	6.21	49.6
1,1,1-TRICHLOROETHANE	4/16	2.54	4.00
TRICHLOROETHENE	14/16	81.8	12000
XYLENES, TOTAL	5/16	4.27	25.0
SEMI-VOLATILES			
ACENAPHTHENE	1/16	NR	93.0
ACENAPHTHLYENE	1/16	NA	497
ANTHRACENE	5/16	116	514
BENZO(a)ANTHRACENE	5/16	189	1120
BENZO(a)PYRENE	5/16	192	1040
BENZO(b)FLUORANTHENE	4/16	233	2230
BENZO(g,h,i)PERYLENE	1/16	NA	812
BENZO(k)FLUORANTHENE	3/16	171	360
BIS(2-ETHYLHEXYL)PHTHALATE	10/14	407	9350
BUTYLBENZYL PHTHALATE	2/16	175	287
CHRYSENE	5/16	194	935
DI-N-BUTYLPHTHALATE	7/14	409	3000
FLUORANTHENE	6/15	215	1260
INDENO(1,2,3-CD)PYRENE	5/16	176	862
2-METHYLNAPHTHALENE	2/16	163	240
NAPHTHALENE	3/16	164	237
N-NITROSODIPHENYLAMINE	1/12	NR	120
CARCINOGENIC PAHS, TOTAL	6/16	1100	6090
NONCARCINOGENIC PAHS, TOTAL	8/16	713	3830
PHENANTHRENE	6/16	180	560
PHENOL	1/16	174	400
PYRENE	8/14	199	1100
PESTICIDES/PCBS/DIOXINS			
4,4'-DDE	3/16	12.2	570
4,4'-DDD	2/16	10.9	240
4,4'-DDT	4/16	14.7	210
CHLORDANE	3/14	68.1	23000
GAMMA-BHC (LINDANE)	1/16	4.99	137
AROCLOR-1254	4/15	228	130000
AROCLOR-1260	1/16	89.6	490
HpCDD	1/6	NA	3.70
OCDD	1/6	NA	38.2

NA = Not applicable; mean not calculated with only one positive detection.

NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

TABLE 6-1 (continued)

COMPOUNDS DETECTED IN SURFACE SOILS AT THE WILDWOOD
CONSERVATION CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
INORGANICS (mg/kg)			
==========			
ALUMINUM	16/16	5420	11200
ANTIMONY	2/16	3.77	29.4
ARSENIC	16/16	7.31	60.7
BARIUM	16/16	39.3	886
BERYLLIUM	3/16	0.28	0.52
CADMIUM	7/16	0.72	27.2
CALCIUM	16/16	847	3560
CHROMIUM	16/16	45.5	3060
COBALT	3/16	3.09	12.0
COPPER	15/16	17.2	181
IRON	16/16	5940	20500
LEAD	16/16	31.0	683
MAGNESIUM	16/16	792	5170
MANGANESE	16/16	55.3	262
MERCURY	5/16	0.04	5.50
NICKEL	7/16	4.41	23.0
POTASSIUM	14/16	329	1590
SODIUM	9/16	148	250
VANADIUM	15/16	11.7	36.7
ZINC	16/16	58.0	1240
CYANIDE	2/16	0.65	18.0

NA = Not applicable; mean not calculated with only one positive detection.

NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

TABLE 6-2

COMPOUNDS DETECTED IN SUBSURFACE SOILS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/kg)			
VOLATILES			
ACETONE	7/9	45.7	1000
2-BUTANONE	2/14	6.21	71.0
TRANS-1,2-DICHLOROETHENE	3/14	6.18	1600
ETHYLBENZENE	3/14	3.22	13.0
METHYLENE CHLORIDE	3/14	4.52	650
TETRACHLOROETHENE	5/14	13.2	6400
TOLUENE	6/14	3.52	34.0
TRICHLOROETHENE	10/14	52.5	25000
XYLENES, TOTAL	5/14	4.34	68.0
SEMI-VOLATILES			
ANTHRACENE	1/14	NA	520
BENZO(a)PYRENE	2/14	172	1400
BENZO(b)FLUORANTHENE	1/14	NA	1600
BIS(2-ETHYLHEXYL)PHTHALATE	12/14	331	8900
BUTYLBENZYL PHTHALATE	4/14	218	1100
CHRYSENE	1/14	NR	39.0
DI-N-BUTYLPHTHALATE	6/14	311	1900
FLUORANTHENE	1/14	NA	790
2-METHYLNAPHTHALENE	1/14	NA	1300
NAPHTHALENE	1/14	NA	1700
CARCINOGENIC PAHs, TOTAL	2/14	514	3520
NONCARCINOGENIC PAH's, TOTAL	1/14	NA	3790
PENTACHLOROPHENOL	1/14	NA	230
PESTICIDES/PCB'S			
CHLORDANE	2/14	72.5	96000
AROCLOR-1254	6/14	149	81000
INORGANICS (mg/kg)			
ALUMINUM	14/14	3840	8450
ARSENIC	11/14	2.90	44.0
BARIUM	12/14	16.2	343
BERYLLIUM	2/14	0.27	0.48
CADMIUM	6/14	0.63	4.70
CALCIUM	14/14	438	1050
CHROMIUM	14/14	14.6	77.2
COPPER	8/14	3.91	16.3
IRON	14/14	3580	9260
LEAD	13/14	3.48	126
MAGNESIUM	14/14	703	1850
MANGANESE	14/14	32.8	108
MERCURY	2/14	0.02	2.60
NICKEL	3/14	2.88	18.4
POTASSIUM	13/14	248	656
SODIUM	6/14	160	250
VANADIUM	11/14	5.54	13.2
ZINC	13/14	20.6	290
CYANIDE	1/14	NA	1.10

NA = Not applicable; mean not calculated with only one positive detection.

NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

acenaphthylene, anthracene, benzo(g,h,i)perylene, chrysene, fluoranthene, naphthalene, phenanthrene, and pyrene.

The phthalate esters (bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and butyl benzyl phthalate) were detected in both surface and subsurface soils. Bis(2-ethylhexyl)phthalate was detected in the highest concentrations and with the greatest frequency. Hence, it will be selected as a chemical of potential concern.

Several pesticides [chlordane, 4,4'-DDT and its degradation products, (4,4'DDD and 4,4'-DDE), and gamma-hexachlorocyclohexane (Lindane)] and the polychlorinated biphenyls (PCBs) (Aroclor 1254 and Aroclor 1260) were detected in the Wildwood property soils. With the exception of Lindane, which was detected once in the surface soils, all will be selected as chemicals of potential concern. The two PCB Aroclors will be treated collectively as will 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE, referred to subsequently as 4,4'-DDT.

Pentachlorophenol, phenol, N-nitrosodiphenylamine, chloroform, and 2-hexanone are not considered further since they were detected only once in either surface or subsurface soils.

Six soil samples were analyzed for the polychlorinated dibenzo-p-dioxins (PCDDs), as seen on Figure 6-1. In sampling location D6, hepta-chlorodibenzo-p-dioxin (HpCDD) and octachlorodibenzo-p-dioxin (OCDD) were detected at concentrations of 3.7 ng/g and 38.2 ng/g, respectively. These two compounds are members of the PCDD family of compounds, the most biologically active of which is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), which was not detected here. Additionally, the most biologically active congeners tend to be chlorinated at the 2,3,7,8 position. For regulatory purposes, the relative potencies of the other PCDDs are often based on a comparison with 2,3,7,8-TCDD, as discussed in Appendix A.

The toxicity equivalence factors (TEFs) for the congeners detected here are 0.0037 ng/g conservatively assuming all the HpCDD is 2,3,7,8-HpCDD and the OCDD concentration is 0 ng/g. The total 2,3,7,8-TCDD equivalent concentration is 0.0037 ng/g which is well below the 1 ng/g typical soil action levels for this class of compounds (Kimbrough 1984, EPA 1988d). Thus, these two compounds were not selected as chemicals of potential concern.

Numerous inorganic constituents were detected in the Wildwood soils. The concentrations of all the inorganic constituents detected in the subsurface soils fell within background ranges and hence will not be discussed further. Barium, cadmium, chromium, lead, mercury and zinc were detected at concentrations which exceed the range of typical soils (Table A-1 of Appendix A). Barium was detected at a geometric mean concentration which fell within both background ranges and at a maximum concentration which fell within the range of maximums of Massachusetts and Eastern United States soils (Connor and Shacklette 1975, Shacklette and Boerngen 1984). Thus, barium was not selected as a chemical of potential concern. The geometric mean cadmium concentration was within the background range (Connor and Shacklette 1975) but the maximum concentration exceeded the maximum background concentration by almost a factor of 30. As a result, cadmium was selected as a soil chemical of potential concern. Chromium was detected at geometric mean concentrations which fell within the background range for both Massachusetts and Eastern U.S. soils (Connor and Shacklette 1975, Shacklette and Boerngen 1984). The maximum concentration exceeded the maximum background concentration by at least a factor of 10. Therefore, chromium was selected as a chemical of potential concern. Mercury was detected at geometric mean and maximum concentrations which fell within the background range and were less than twice the maximum background concentration, respectively. Mercury was not selected as a chemical of potential concern. Lead was selected as a chemical of potential concern becuase its geometric mean and maximum concentrations exceeded Massachusetts background ranges (Shacklette and Boerngen 1984) and twice the maximum Eastern U.S. concentration. Zinc was not selected as a chemical of potential concern because it is an essential nutrient and its maximum concentration fell within the acceptable range of ten times the maximum background concentration. To summarize, cadmium, chromium, and lead were selected as chemicals of potential concern. Additionally, all the inorganic subsurface soil concentrations were detected within the range for background soil with the exception of cadmium and lead.

The chemicals of potential concern for the surface soils at the Wildwood Conservation Corporation property are: acetone, bis(2-ethylhexyl)phthalate, cadmium, chlordane, chromium, 4,4-DDT, trans-1,2-dichloroethene, lead, methylene chloride, carcinogenic PAHs, noncarcinogenic PAHs, PCBs, tetrachloroethene, toluene, and trichloroethene.

The northern sludge samples include SL-09, SL-10, and SL-11 (a duplicate of SL-10). Chloroform, ethylbenzene, toluene, and total xylenes were the only volatile organic compounds detected in these samples as seen in Table 6-3. The last three have similar health endpoints in humans, xylene was detected in the highest concentrations and was selected as a chemical of potential concern, representing these three compounds. Chloroform was also selected as a chemical of potential concern.

Numerous semivolatile organics were also detected in the northern sludge samples. Of the three phenolic compounds detected, phenol and pentachlorophenol were selected as chemicals of potential concern. 2-Methylphenol was not selected as a chemical of potential concern due to insufficient information on its toxicity. Bis(2-ethylhexyl)phthalate was selected as a chemical of potential concern, representing the class of phthalate esters. The PAHs were divided into groups as potentially carcinogenic PAHs and noncarcinogenic PAHs and selected as chemicals of potential concern.

The pesticides, chlordane, 4,4'-DDT, 4,4'-DDD, 4,4'-DDE, endrin, and lindane, were detected in the northern sludge samples. Of these, chlordane and 4,4'-DDT and its degradation products were selected as chemicals of potential concern since they were detected in the highest concentration.

The inorganic constituents detected in the northern sludge samples were, with the exception of cadmium, chromium, and lead detected at levels that are generally found in soils [i.e., the geometric mean concentration fell within the background ranges and the maximum concentration was less than twice (or ten times for the essential nutrients) the maximum background concentration].

TABLE 6-3
COMPOUNDS DETECTED IN NORTHERN SLUDGES AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/kg)			
VOLATILES			
CHLOROFORM	1/2	NA	3150
ETHYLBENZENE	1/2	NA	9500
TOLUENE	1/2	NA	2390
XYLENES, TOTAL	1/2	NA	61000
SEMI-VOLATILES			
BENZOIC ACID	1/2	NA	80000
BENZO(a)ANTHRACENE	1/2	NA	20300
BENZO(b)FLUORANTHENE	1/2	NA	1800
BENZO(k)FLUORANTHENE	1/2	NA	1200
BIS(2-ETHYLHEXYL)PHTHALATE	1/2	NA	37000
BUTYLBENZYL PHTHALATE	1/2	NA	3100
CHRYSENE	1/2	NA	38900
DIBENZOFURAN	1/2	NA	20400
DIETHYL PHTHALATE	1/2	NA	1300
DI-N-BUTYL PHTHALATE	1/2	NA	5600
DI-N-OCTYL PHTHALATE	1/2	NA	2200
FLUORANTHENE	2/2	6710	12800
FLUORENE	1/2	NA	60000
2-METHYLNAPHTHALENE	2/2	116000	484000
2-METHYLPHENOL	1/2	NA	1070
NAPHTHALENE	2/2	36700	89600
CARCINOGENIC PAHs, TOTAL	2/2	14600	59200
NONCARCINOGENIC PAH's, TOTAL	2/2	259000	966000
PENTACHLOROPHENOL	1/2	NA	6400
PHENANTHRENE	2/2	52600	184000
PHENOL	1/2	NA	9800
PYRENE	2/2	29900	115000
PESTICIDES/PCB'S			
GAMMA-BHC	1/2	NA	1300
4,4'-DDT	1/2	NA	15000
4,4'-DDE	1/2	NA	4700
ENDRIN	1/2	NA	2900
CHLORDANE	2/2	6620	81000
INORGANICS (mg/kg)			
ALUMINUM	2/2	780	1330
ARSENIC	2/2	16.9	86.0
BARIUM	2/2	294	423
CADMIUM	2/2	3.46	13.0
CALCIUM	2/2	2310	7900
CHROMIUM	2/2	270	802
COBALT	1/2	NA	279
COPPER	2/2	35.4	77.0
IRON	2/2	10400	39900
LEAD	2/2	819	6180
MAGNESIUM	2/2	580	1250
MANGANESE	2/2	54.2	173
MERCURY	2/2	0.38	2.30
NICKEL	2/2	14.4	17.0
SODIUM	2/2	454	880
TIN	2/2	16.9	45.0
VANADIUM	2/2	43.5	105
ZINC	2/2	280	742

NA = Not applicable; mean not calculated with only one positive detection.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

Thus, cadmium, chromium, and lead were selected as a chemical of potential concern for the northern sludge samples.

Thus, the chemicals of potential concern for the northern sludges are bis (2-ethylhexyl)phthalate, cadmium, chlordane, chloroform, chromium, 4,4'-DDT, lead, carcinogenic PAHs, noncarcinogenic PAHs, pentachlorophenol, phenol, and xylenes.

The southern sludge samples included SL-01 to SL-08. The contamination in these sludges (Table 6-4) was somewhat different than that found in the northern sludge samples (Table 6-3). The southern sludges contained the volatile compounds: trans-1,2-dichloroethene, 2-hexanone, tetrachloroethene, toluene, 1,1,1-trichloroethane, and trichloroethene. All of these compounds will be selected as chemicals of potential concern with the exception of 2-hexanone since it was detected at a concentration near its analytical detection limit. Several semivolatile organic compounds were detected in the southern sludge samples. Of these compounds, pentachlorophenol, bis(2-ethylhexyl)phthalate, and the carcinogenic and noncarcinogenic PAHs were selected as chemicals of potential concern. Chlordane and 4,4'-DDT and its degradation products were selected as chemicals of potential concern, representing the pesticide class of compounds. Cadmium, chromium, and lead were selected as chemicals of potential concern since they were the only inorganic constituents detected above the typical range of inorganics in soil [i.e., either the geometric mean concentration was above background ranges and/or the maximum concentration was more than twice (or ten times for essential nutrients) the maximum background concentrations]. Tin was detected once at a level higher than background but within the range of twice the maximum background concentration and was therefore not selected as a chemical of concern.

The southern sludge chemicals of potential concern are bis(2-ethylhexyl) phthalate, cadmium, chlordane, chromium, 4,4'-DDT, trans-1,2-dichloroethene, lead, carcinogenic PAHs, noncarcinogenic PAHs, pentachlorophenol, tetrachloroethene, toluene, 1,1,1-trichloroethane, and trichloroethene.

TABLE 6-4

COMPOUNDS DETECTED IN SOUTHERN SLUDGES AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/liter)			
ACENAPHTHYLENE	1/8	NA	2400
BENZO(a)PYRENE	1/8	NA	3700
BENZO(q,h,i)PERYLENE	1/8	NA	9200
BIS(2-ETHYLHEXYL)PHTHALATE	4/8	1260	150000
BUTYLBENZYL PHTHALATE	1/8	NA	38000
CHLORDANE	1/6	NA	20000
4,4'-DDE	1/8	NA	890
4,4'-DDT	3/8	70.9	320000
1,2-DICHLOROETHENE	1/8	NA	120
DIELDRIN	1/8	NA	32.0
DIETHYL PHTHALATE	1/8	NA	5500
DI-N-BUTYL PHTHALATE	2/8	363	26000
FLUORANTHENE	1/8	NA	4400
2-HEXANONE	1/8	NA	12.0
INDENO(1,2,3-CD)PYRENE	3/8	563	9200
2-METHYLNAPHTHALENE	2/8	463	16000
4-METHYLPHENOL	1/8	NA	14000
NAPHTHALENE	1/8	NA	3500
CARCINOGENIC PAHs, TOTAL	4/8	4180	9200
NONCARCINOGENIC PAH's, TOTAL	5/8	6050	38000
PENTACHLOROPHENOL	1/8	NA	110000
PYRENE	4/8	766	12000
TETRACHLOROETHENE	1/8	NA	86000
TOLUENE	1/6	NA	1500
1,1,1-TRICHLORETHANE	1/8	NA	11000
TRICHLOROETHENE	2/8	13.3	15000
INORGANICS (mg/kg)			
ALUMINUM	8/8	1570	6660
ARSENIC	8/8	8.40	82.0
BARIUM	8/8	136	1520
BERYLLIUM	2/8	0.29	0.50
CADMIUM	3/8	0.66	18.0
CALCIUM	8/8	420	1630
CHROMIUM	8/8	41.6	410
COPPER	7/8	16.3	146
IRON	8/8	8030	22400
LEAD	8/8	638	10000
MAGNESIUM	7/8	1001	3290
MANGANESE	8/8	55.5	141
MERCURY	4/8	0.08	3.60
NICKEL	5/8	6.52	26.0
POTASSIUM	7/8	674	2000
SODIUM	8/8	141	2350
TIN	1/8	NA	25.0
VANADIUM	6/8	14.5	54.0
ZINC	8/8	74.2	1160
CYANIDE	1/8	NA	2.30

NA = Not applicable; mean not calculated with only one positive detection.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

The complete list of soil and sludge chemicals of potential concern for the Wildwood Conservation Corporation Property are acetone, bis(2-ethylhexyl) phthalate, cadmium, chlordane, chloroform, chromium, 4,4'-DDT, trans-1,2-dichloroethene, lead, methylene chloride, carcinogenic PAHs, noncarcinogenic PAHs, PCBs, pentachlorophenol, phenol, tetrachloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, and xylene.

6.1.2 GROUNDWATER

The groundwater at the Wildwood property contains a number of volatile organic compounds, as seen in Table 6-5. The most frequently detected compounds are trichloroethene, tetrachloroethene, trans-1,2-dichloroethene, 1,1,1-trichloroethane, chloroform, and xylenes. All of these compounds were selected as chemicals of potential concern. In addition, vinyl chloride was selected as a chemical of concern because it is formed by the microbial degradation of tetrachloroethene and trichloroethene, as discussed in Appendix B of this endangerment assessment. 1,2-Dichlorobenzene and bis(2-ethylhexyl)phthalate were the most frequently detected semivolatile organic compounds. Bis(2-ethylhexyl)phthalate was not selected as a chemical of potential concern because it was detected at very low levels, as is expected due to its relatively low solubility and high organic carbon partition coefficient (K_{oc}), as discussed in Appendix B. 1,2-Dichlorobenzene was selected as a chemical of potential concern. Acetone, benzoic acid, 2-butanone, chlordane, 1,2-dichloroethane, 1,1-dichloroethane, methylene chloride, noncarcinogenic PAHs and toluene were not considered chemicals of potential concern since they were detected infrequently (i.e., in less than 5% of the samples).

A number of inorganic constituents were detected in the groundwater at levels that exceeded the typical levels detected in groundwater (Table A-2 of Appendix A). Cadmium, iron, and manganese were detected at levels that exceed background. Cadmium was not selected as a chemical of potential concern due to its limited frequency of detection and the fact that the concentration only slightly exceeded background. Iron was not selected because it is an essential nutrient, and its concentrations were within the acceptable range

TABLE 6-5

COMPOUNDS DETECTED IN GROUNDWATER AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/liter)			
ACETONE	1/18	NA	4570
BENZOIC ACID	1/23	NA	50.0
BIS(2-ETHYLHEXYL) PHTHALATE	3/18	NR	4.00
2-BUTANONE	1/17	NR	1.30
CHLORDANE	1/19	NR	0.03
CHLOROFORM	10/27	17.5	6000
1,2-DICHLOROBENZENE	6/22	7.02	160
1,1-DICHLOROETHANE	2/42	2.78	28.0
1,2-DICHLOROETHANE	1/42	NA	4.00
TRANS-1,2-DICHLOROETHENE	11/40	10.0	4510
ETHYLBENZENE	5/41	7.02	1000
2-METHYLNAPHTHALENE	2/22	NR	3.10
METHYLENE CHLORIDE	1/9	NA	1250
NAPHTHALENE	2/22	4.80	5.20
TETRACHLOROETHENE	13/41	7.58	58000
TOLUENE	1/39	NA	3400
1,1,1-TRICHLOROETHANE	14/34	16.6	7800
TRICHLOROETHENE	37/42	656	440000
VINYL CHLORIDE	3/42	7.53	300
XYLENES, TOTAL	11/42	19.1	14000
NONCARCINOGENIC PAH's,TOTAL	2/23	5.60	8.30
INORGANICS (ug/liter)			
ALUMINUM	2/3	516	2160
ARSENIC	1/3	NA	5.00
BARIUM	3/3	13.8	30.0
CADMIUM	1/3	NA	8.10
CALCIUM	3/3	26000	27300
IRON	3/3	388	11300
MAGNESIUM	3/3	5770	6730
MANGANESE	3/3	470	2200
POTASSIUM	3/3	1900	2030
SODIUM	3/3	26200	36400
ZINC	3/3	27.60	44.4

NA = Not applicable; mean not calculated with only one positive detection.

NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

for essential nutrients, as discussed in Appendix A. Thus, only manganese was selected as a chemical of potential concern. It should be noted that the geometric mean and maximum concentrations of sodium exceeded the Massachusetts advisory level of 20,000 ug/liter for persons on a low salt diet.

The chemicals of potential concern for goundwater are chloroform, 1,2-dichlorobenzene, trans-1,2-dichloroethene, manganese, tetrachloroethene, 1,1,1-trichloroethane, trichloroethene, vinyl chloride and xylene.

6.1.3 SUMMARY

Table 6-6 lists the chemicals of potential concern for the Wildwood property. The soil and sludge chemicals of potential concern are acetone, bis(2-ethylhexyl)phthalate, cadmium, chlordane, chloroform, chromium, 4,4'-DDT, trans-1,2-dichloroethene, lead, methylene chloride, carcinogenic PAHs, noncarcinogenic PAHs, PCBs, pentachlorophenol, phenol, tetrachloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, and xylene. The groundwater chemicals of potential concern are chloroform, trans-1,2-dichloroethene, 1,2-dichlorobenzene, manganese, tetrachloroethene, 1,1,1-trichloroethane, trichloroethene, vinyl chloride, and xylene.

6.2 EXPOSURE ASSESSMENT

6.2.1 PROPERTY UNDER CURRENT-USE CONDITIONS

Under current-use conditions, exposure to chemicals originating in the soil will be evaluated. Groundwater is not currently used for drinking water purposes. Thus, this pathway is not considered to be complete and will not be evaluated herein. The property is currently fenced and thus the soil exposure scenario will evaluate exposure to concentrations currently detected at the site assuming the fence could be removed at some time in the future. Since this scenario evaluates current conditions, it is considered under the current-use conditions.

TABLE 6-6

CHEMICALS OF POTENTIAL CONCERN
FOR THE WILDWOOD CONSERVATION CORPORATION PROPERTY

SOIL	SLUDGES	GROUNDWATER
Acetone	Bis(2-ethylhexyl)-phthalate[a,b]	Chloroform
Bis(2-ethylhexyl)phthalate	Cadmium[a,b]	trans-1,2-Dichloroethene
Cadmium	Chlordane[a,b]	1,2-Dichlorobenzene
Chlordane	Chloroform[a]	Manganese
Chromium	Chromium[a,b]	Tetrachloroethene
4,4'-DDT	4,4'-DDT[a,b]	1,1,1-Trichloroethane
trans-1,2-Dichloroethene	trans-1,2-Dichloroethene[b]	Trichloroethene
Lead	Lead[a,b]	Vinyl chloride
Methylene chloride	cPAHs[a,b,c]	Xylene
cPAHs[c]	nPAHs[a,b,c]	
nPAHs[d]	Pentachlorophenol[a,b]	
PCBs[e]	Phenol[a]	
Tetrachloroethene	Tetrachloroethene[b]	
Toluene	Toluene[b]	
Trichloroethene	1,1,1-Trichloroethane[b]	
	Trichloroethene[b]	
	Xylene[a]	

[a]Chemical of potential concern for the northern sludges.
[b]Chemical of potential concern for the southern sludges.
[c]Potentially carcinogenic polynuclear aromatic hydrocarbons.
[d]Noncarcinogenic polynuclear aromatic hudrocarbons.
[e]Polychlorinated biphenyls.

Exposure to individuals trespassing onto the property will include both incidental ingestion of soil as well as dermal absorption of contaminants through the skin. Under average exposure conditions, it is assumed that an individual will be at this property five days per week for four months or 100 per year for six years. Under plausible maximum conditions, an individual is assumed to frequent the site seven days per week for six months or 168 days per year for six years. The soil concentrations of the chemicals of potential concern are summarized in Table 6-7. The sludge concentrations for the chemicals of potential concern are summarized in Table 6-8.

The contaminated soils can act as a source of volatile organics to the air. Additionally, although the site is currently fenced, it is possible that the fence could be cut and young adults with dirt bikes could ride on the unpaved road at this property. Thus, these two air pathways will be assessed here.

The volatilization of chemicals from the soil is dependent upon soil conditions and the physicochemical properties of the compound. Highly organic soils retard diffusion and mass transport because the soil particles can act to sorb the organic compounds to them. This effect is more significant for semivolatile compounds, such as bis(2-ethylhexyl)phthalate, than volatiles such as trichloroethene (Urano and Murata 1985). Highly porous and dry soils have a higher diffusion rate because there are more air spaces for the organic compounds to move through. A mathematical model (Karimi 1987) summarized in Appendix C was used to calculate the emission rate due to soil volatilization of organic contaminants in the Wildwood Conservation Corp. property soils and sludges. Table 6-9 summarizes the results of the model.

Dust can be generated during dirt bike riding and inhaled by the bike rider or by other individuals present in the area. For this exposure scenario, it is assumed that four dirt bike riders use the property. The methodology used to evaluate this scenario is summarized in Appendix C and is derived from that of Cowherd et al. (1984). Table 6-9 also presents the concentrations of the chemicals of potential concern found in dust resulting from this scenario.

TABLE 6-7

SOIL CONCENTRATIONS FOR THE CHEMICALS OF POTENTIAL CONCERN
FOR THE WILDWOOD CONSERVATION CORPORATION PROPERTY

COMPOUND	CONCENTRATION (ug/kg) GEOMETRIC MEAN	MAXIMUM
Acetone	81.4	1200
Bis(2-ethylhexyl)phthalate	407	9349
Cadmium	720	27200
Chlordane	68.1	23000
Chromium	45500	3060000
4,4'-DDT[a]	45.1	1020
trans-1,2-Dichloroethene	4.07	89.0
Lead	31000	683000
Methylene chloride	22.1	670
cPAHs[b]	1100	6090
nPAHs[c]	713	3830
PCBs[d]	386	130500
Tetrachloroethene	7.44	2000
Toluene	6.21	49.6
Trichloroethene	81.8	11960

[a]The concentration reported for 4,4'-DDT includes the concentrations of 4,4'-DDD and 4,4'-DDE.

[b]Potentially carcinogenic polynuclear aromatic hydrocarbons; includes concentrations of benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-c,d)pyrene.

[c]Noncarcinogenic polynuclear aromatic hydrocarbons; includes concentrations of acenaphthene, acenaphthylene, anthracene, benzo(g,h,i)perylene, chrysene, fluoranthene, naphthalene, phenanthrene, and pyrene.

[d]Polychlorinated biphenyls; includes concentrations of Aroclor 1254 and Aroclor 1260.

TABLE 6-8

SLUDGE CONCENTRATIONS FOR THE CHEMICALS OF POTENTIAL CONCERN FOR THE WILDWOOD CONSERVATION CORPORATION PROPERTY

COMPOUND	CONCENTRATION (ug/kg)	
	GEOMETRIC MEAN	MAXIMUM
NORTHERN SLUDGES		
Bis(2-ethylhexyl)phthalate	NA	37000
Cadmium	3460	13000
Chlordane	6620	81000
Chloroform	NA	3150
Chromium	270000	802000
4,4'-DDT[a]	NA	19700
Lead	819000	6180000
cPAHs[b]	14600	59200
nPAHs	259000	966000
Pentachlorophenol	NA	6400
Phenol	NA	9800
Xylene	NA	61000
SOUTHERN SLUDGES		
Bis(2-ethylhexyl)phthalate	1260	150000
Cadmium	660	18000
Chlordane	NA	20000
Chromium	41600	410000
4,4'-DDT[a]	128	321000
trans-1,2-Dichloroethene	NA	120
Lead	638000	10000000
cPAHs[b]	4180	9200
nPAHs	6050	38000
Pentachlorophenol	NA	110000
Tetrachloroethene	NA	86000
Toluene	NA	1500
1,1,1-Trichloroethane	NA	11000
Trichloroethene	13.3	15000

NA = Not applicable; geometric mean not calculated with only one positive detection.
[a]The concentration reported for 4,4'-DDT includes the concentrations of 4,4'-DDE.
[b]Potentially carcinogenic polynuclear aromatic hydrocarbons; includes concentrations of benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-c,d)pyrene.
[c]Noncarciongenic polynuclear aromatic hydrocarbons; includes concentrations acenaphthene, acenaphthylene, penanthrene, and pyrene.

TABLE 6-9

AIR CONCENTRATIONS RESULTING FROM VOLATILIZATION AND VEHICULAR TRAFFIC EMISSIONS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

	CONCENTRATION (mg/m^3)			
	Volatilization		Dust	
CHEMICAL	Mean	Maximum	Mean	Maximum
SURFACE SOILS				
Acetone	5.79E-04	8.54E-03	2.20E-09	3.24E-08
Bis(2-ethylhexyl)phthalate	2.70E-10	6.21E-09	1.10E-08	2.53E-07
Cadmium	NAP	NAP	1.95E-08	7.35E-07
Chlordane	2.27E-06	7.68E-04	1.84E-09	6.22E-07
Chromium	NAP	NAP	1.23E-06	8.27E-05
4,4'-DDT	1.45E-08	3.57E-07	1.12E-09	2.76E-08
trans-1,2-Dichloroethene	1.68E-04	3.67E-03	1.10E-10	2.41E-09
Lead	NAP	NAP	8.38E-07	1.85E-05
Methylene chloride	2.08E-03	6.30E-02	5.98E-10	1.81E-08
cPAHs	5.35E-11	2.96E-10	2.97E-08	1.65E-07
nPAHs	1.06E-04	5.71E-04	1.93E-08	1.04E-07
PCBs	1.52E-07	5.12E-05	1.04E-08	3.52E-06
Tetrachloroethene	1.29E-04	3.47E-02	2.01E-10	5.41E-08
Toluene	3.97E-03	3.17E-04	1.68E-07	1.34E-09
Trichloroethene	1.74E-03	2.55E-01	2.21E-09	3.23E-07
NORTHERN SLUDGES				
Bis(2-ethylhexyl)phthalate	NA	1.08E-09	NA	1.01E-06
Cadmium	NAP	NAP	9.41E-08	3.53E-07
Chlordane	9.46E-06	1.16E-04	1.80E-07	2.20E-06
Chloroform	NA	5.43E-02	NA	8.55E-08
Chromium	NAP	NAP	7.34E-06	2.18E-05
4,4'-DDT	NA	2.95E-07	NA	5.36E-07
Lead	NAP	NAP	2.23E-05	1.68E-04
cPAHs	3.00E-11	1.20E-10	3.97E-07	1.61E-06
nPAHs	1.65E-03	6.16E-03	7.04E-06	2.63E-05
Pentachlorophenol	NA	2.91E-09	NA	1.74E-07
Phenol	NA	4.44E-06	NA	2.66E-07
Xylenes	NA	2.03E-02	NA	1.66E-06

TABLE 6-9 (Continued)

AIR CONCENTRATIONS RESULTING FROM VOLATILIZATION AND VEHICULAR TRAFFIC EMISSIONS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

	CONCENTRATION (mg/m^3)			
	Volatilization		Dust	
CHEMICAL	Mean	Maximum	Mean	Maximum
<u>SOUTHERN SLUDGES</u>				
Bis(2-ethylhexyl)phthalate	NA	1.37E-08	NA	4.06E-06
Cadmium	NAP	NAP	1.89E-08	4.87E-07
Chlordane	NA	8.79E-04	NA	5.41E-07
Chromium	NAP	NAP	1.12E-06	1.11E-05
4,4'-DDT	NA	1.48E-05	1.74E-08	8.65E-06
<u>trans</u>-1,2-dichloroethene	NA	6.50E-04	NA	3.24E-09
Lead	NAP	NAP	1.73E-05	2.70E-04
cPAHs	2.68E-11	5.89E-11	6.09E-08	2.71E-07
nPAHs	1.19E-04	7.45E-04	1.64E-07	1.03E-06
Pentachlorophenol	NA	1.54E-07	NA	2.97E-06
Tetrachloroethene	NA	1.96E-01	NA	2.33E-06
Toluene	NA	1.26E-03	NA	4.06E-08
1,1,1-Trichloroethane	NA	7.88E-02	NA	2.97E-07
Trichloroethene	3.72E-04	4.20E-02	3.60E-10	4.06E-07

NA = Not applicable; geometric mean not calculated for only one positive detection.

NAP = Not applicable; inorganics are not volatile.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

6.2.2 PROPERTY UNDER FUTURE-USE CONDITIONS

In the absence of institutional controls limiting access of future uses of the Wildwood property, there are additional exposure pathways that must be evaluated. It is possible that in the future, this property will be developed. Future land use involving excavations for utilities or construction would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short term compared with the exposure scenario developed for teenagers or young adults under current-use conditions, although workers could be exposed to higher concentrations over the much shorter time frame (e.g., one or two months). Therefore, this scenario will not be quantified.

It is also possible that in the future, this property will be developed for residential purposes. Should this occur, the potential exists for residents living on the property to be exposed to contaminated soils during outdoor activities. Exposure is assumed to occur via direct contact with contaminated soils with subsequent ingestion and dermal absorption of chemicals. The soil and sludge concentrations in Table 6-7 and Table 6-8 will be used herein. This provides a conservative evaluation because the concentrations of the volatile organic compounds will decrease with time. Because these exposures are assumed to occur over a lifetime, time-weighted averages for the amount of soil ingested per exposure event, the dermal soil contact rate, and an individual's body weight were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime.

While an individual resident is outdoors, exposure to volatile organics present in the soil may occur. This exposure scenario provides a conservative estimate of exposure because it assumes that the concentrations of the chemicals of potential concern in soil remain constant over time. In reality, these concentrations will decrease over time. Dust exposure which was evaluated under current conditions was not evaluated for the future-use scenario since it is assumed that much of the site will be unavailable for dirt bike riding. The individual inhalation rate is averaged over a lifetime, as in the direct contact with soil exposure scenario, to account for age variations. The air concentrations derived under the current-use scenario for volatilization (Table 6-9) are assumed to apply here. It should be noted that this scenario does not consider inhalation exposure of volatiles which could migrate from outdoors into the home. Thus, in terms of total exposure, this scenario may underestimate exposure and risk.

It is also possible that in the future a well to be used for drinking water purposes will be installed at the Wildwood property. Thus, another exposure scenario would involve the ingestion of groundwater. Should this water be used in a residential setting, exposures could occur via inhalation and dermal contact from bathing or showering, washing clothes, cooking, washing dishes, and any other household activities which involve the use of water. In this endangerment assessment, exposure via ingestion and dermal contact and inhalation while showering will be evaluated. The groundwater exposure point concentrations are summarized in Table 6-10.

The groundwater concentrations of the chemicals of potential concern summarized in Table 6-10 were used to estimate the concentrations that might be expected to occur while showering. Using a theoretical exposure model outlined in Appendix C (Foster and Chrostowski 1986, 1987), the transfer of volatile organic compounds from shower droplets into the air and their subsequent inhalation were estimated. Based on this exposure model, the potential inhalation exposures to the groundwater contaminants which could volatilize were quantified. Manganese is not volatile and hence are not evaluated in this exposure scenario. The model does not estimate dermal absorption of contaminants while showering. However, given the exposure scenario and the physical and chemical properties of the organic compounds considered in this assessment, dermal absorption is likely to result in minimal exposure as compared to exposure via inhalation. The model estimates the intake level (in mg/kg/day), rather than the ambient air concentrations that might be expected while showering. These values are presented in Table 6-11 for the geometric mean and maximum concentrations of the contaminants in groundwater.

TABLE 6-10

GROUNDWATER CONCENTRATIONS FOR THE CHEMICALS OF POTENTIAL CONCERN
FOR THE WILDWOOD CONSERVATION CORPORATION PROPERTY

(ug/liter)

COMPOUND	CONCENTRATION	
	GEOMETRIC MEAN	MAXIMUM
Chloroform	17.5	6000
trans-1,2-Dichloroethene	10.0	4510
1,2-Dichlorobenzene	7.0	160
Manganese	470	2200
Tetrachloroethene	7.6	58000
1,1,1-Trichloroethane	16.6	7800
Trichloroethene	656	440000
Vinyl chloride	7.5	300
Xylene	19.1	14000

TABLE 6-11

INTAKES OF THE CHEMICALS OF POTENTIAL CONCERN WHILE SHOWERING WITH GROUNDWATER FROM THE WILDWOOD CONSERVATION CORPORATION PROPERTY

COMPOUND	INTAKE (mg/kg/day)	
	GEOMETRIC MEAN	MAXIMUM
Chloroform	$4.44x10^{-4}$	$1.52x10^{-1}$
1,2-Dichlorobenzene	$1.56x10^{-4}$	$3.57x10^{-3}$
trans-1,2-Dichloroethene	$2.80x10^{-4}$	$1.26x10^{-1}$
Tetrachloroethene	$1.77x10^{-4}$	1.35
1,1,1-Trichloroethane	$4.21x10^{-4}$	$1.98x10^{-1}$
Trichloroethene	$1.65x10^{-2}$	11.1
Vinyl chloride	$2.51x10^{-4}$	$1.01x10^{-2}$
Xylene	$5.18x10^{-4}$	$3.79x10^{-1}$

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

6.3 RISK ASSESSMENT

According to guidelines for preparing risk assessments as part of the RI/FS process (EPA 1986a), the potential adverse effects on human health should first be assessed where possible by comparing chemical concentrations found in environmental media at or near the site with applicable or relevant and appropriate requirements (ARARs) or other guidance that has been developed for the protection of human health or the environment. If ARARs are not available for all chemicals and exposures considered, quantitative risk estimates must be developed in addition to the comparison to ARARs. This section will present a comparison of exposure point concentrations to the applicable or relevant and appropriate requirements (ARARs) as well as a quantitative risk assessment.

6.3.1 COMPARISON TO APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER GUIDANCE LEVELS

In this section, the concentrations of chemicals of potential concern in groundwater at the Wildwood Conservation Corporation property are compared to ARARs. Table 6-12 presents this comparison, and as can be seen from the table, the geometric mean and maximum concentrations of manganese, trichloroethene, and vinyl chloride exceed their MCLs. It should be noted that the MCL for manganese is a secondary standard which is not federally enforseable and is based on organoleptic considerations. Only the maximum concentrations of chloroform and 1,1,1-trichloroethane exceed their MCLs.

For those chemicals without MCLs, a comparison can be made to the other guidance levels available. The maximum concentrations of trans-1,2-dichloroethene and xylene exceed their respective Massachusetts drinking water standard, and both the geometric mean and maximum concentrations of tetrachloroethene and 1,2-dichlorobenzene exceed their Massachusetts drinking water standards. There are no ARARs for soil.

TABLE 6-12

COMPARISON OF CHEMICALS OF POTENTIAL CONCERN IN THE GROUNDWATER AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY WITH ARARS AND OTHER GUIDANCE LEVELS

(mg/liter)

Compound	Concentration		ARAR	Massachusetts Drinking Water Standard
	Geometric Mean	Maximum	MCL	
Chloroform	0.00175	6.000	0.1 (a)	0.10 (a)
trans-1,2-Dichloroethene	0.001	4.510	--	0.07 (b,d)
1,2-Dichlorobenzene	0.007	0.160	--	0.60 (b,d)
Manganese	0.47	2.200	0.05 (c)	0.05 (c)
Tetrachloroethene	0.0076	58.000	--	0.005
1,1,1-Trichloroethane	0.0166	7.800	0.20	0.20 (d)
Trichloroethene	0.656	440.000	0.005	0.005
Vinyl Chloride	0.0075	0.300	0.002	0.002
Xylene	0.0191	14.000	--	0.62

(a) For total trihalomethanes; refers to sum of chloroform, dibromochloromethane, bromodichloromethane, and bromoform.
(b) Proposed.
(c) Based on organoleptic considerations.
(d) Shall not exceed health advisories which have been adopted by the Massachusetts Division of Water Pollution Control and/or the EPA. For groundwater, this would equate to the Clean Water Act criteria for human health (drinking water only) or the Safe Drinking Water Act Maximum Concentration Limit Goals, whichever is more stringent.

6.3.2 QUANTITATIVE RISK CHARACTERIZATION

To quantitatively assess the risks to human health associated with the future-use exposure scenarios considered in this assessment, the concentrations of chemicals in relevant environmental media (exposure point concentrations) presented in Section 6.2 are converted to chronic daily intakes (CDIs). CDIs are the amount of a substance taken into the body per unit body weight per unit time, expressed in units of mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA 1986b) and over the exposure period for noncarcinogens (EPA 1986c). Section 1.4.4 summarized the methodology that will be used in this section.

In this section of the risk assessment, the intakes of chemicals of potential concern by potentially exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions such as frequency and duration of exposure. For each exposure scenario evaluated, two exposure cases--an average case and plausible maximum case--are considered. For the average exposure case, geometric mean concentrations are used together with what are considered to be the most likely (although conservative) exposure conditions. For the plausible maximum case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the plausible maximum case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

Chronic daily intakes, excess lifetime cancer risks, and CDI:RfD ratios for the site-related chemicals considered in this assessment, as well as the assumptions and procedures used to calculate these values, are shown below for each scenario evaluated.

6.3.2.1 Property Under Current-Use Conditions

In this section, exposure point concentrations are used to estimate the extent of human exposure to the chemicals of potential concern under the current use conditions at the Wildwood Conservation Corporation property. As has been discussed in Section 6.2, direct contact with contaminated soil and inhalation of volatiles released from soil and dust generated by young adults riding dirt bikes are the exposure pathways that may have a potential impact on human health under current use conditions.

Direct Contact With Contaminated Soil. Under current-use conditions, young adults trespassing on the Wildwood Conservation Corporation property could be exposed to contaminated soils and sludges. Direct contact with the contaminated soils and sludges could lead to dermal contact and absorption of contaminants through the skin, as well as inadvertent ingestion of the compounds.

Table 6-13 presents the assumptions used in assessing exposure via these pathways. These assumptions were based on the exposure pathway analysis presented in Section 6.2 and the best currently available information. EPA standard assumptions for average lifetime (70 years) and adult body weight (70 kg) were used (Anderson et al. 1985). Exposure to both the soils and sludges was evaluated using the same set of exposure assumptions.

Average and plausible maximum incidental ingestion rates for the young adults are 50 and 100 mg/day. The derivation of these rates is discussed in Appendix C, and was based primarily on the work of Lagoy (1987).

Values of 400 mg/day and 990 mg/day are used as the average and plausible maximum estimates of soil contact rates for dermal exposure. These values are contact rates for each exposure event and are based on a consideration of contact rates in mg soil/cm^2 skin (0.5-1.5 mg/cm^2) from Schaum (1984), surface area of parts of the body that are likely to be in contact with soil (e.g., approximately 840 cm^2 for the palms of the hands and 1,140 cm^2 for the forearms) from Anderson et al. (1985), and of certain subjective factors.

TABLE 6-13

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT BY YOUNG ADULTS WITH SOIL SLUDGES AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 day/yr	168 day/yr
Duration of Exposure	6 yr	6 yr
Average Weight	45 kg	45 kg
Average Lifetime	70 yr	70 yr
Incidental Ingestion Rate	50 mg/day	100 mg/day
Percent PAHs, Pesticides, PCBs, Phthalates Absorbed from Ingested Soils	15%	45%
Percent Other Organic Compounds Absorbed from Ingested Soils	100%	100%
Percent Inorganic Compounds Absorbed from Ingested Soils	100%	100%
Soil Contact Rate	400 mg/day	990 mg/day
Percent PAHs, Pesticides, PCBs, Phthalates Absorbed Dermally from Skin	0.3%	3%
Percent Other Organic Compounds Absorbed Dermally from Skin	1%	10%
Percent Inorganic Compounds Absorbed Dermally from Skin	Negligible	Negligible

These are reasonable values, but they are a source of uncertainty in the risk calculation.

The derivation of the absorption factors are summarized in Appendix C. These factors are based upon the likelihood that the chemicals will be adsorbed onto the soil (e.g., pesticides, PAHs, and PCBs) and hence, be less bioavailable than these same chemicals in drinking water, for example.

Using these assumptions, chronic daily intake (CDI) estimates for incidental soil ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Appendix C of this endangerment assessment. The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption. Tables 6-14, 6-15, and 6-16 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with these exposures to surface soils, and the northern and southern sludges, respectively.

The upper bound lifetime excess cancer risks associated with surface soil chemicals exhibiting potential carcinogenic effects are $7x10^{-8}$ (seven in one hundred million) for the average exposure case and $7x10^{-5}$ (seven in one hundred thousand) for the plausible maximum exposure case. The presence of chlordane, the carcinogenic PAHs and PCBs contributed most to the potential risk.

Exposure to chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of average exposure, as the hazard index is less than one. The hazard index exceeded one under plausible maximum exposure conditions primarily due to exposure to lead.

Exposure to the northern sludges resulted in a $8x10^{-7}$ (eight in ten million) and $5x10^{-5}$ (five in one hundred thousand) upper bound lifetime excess cancer risk for the average and plausible maximum exposure cases. In both cases, the risk was due primarily to the presence of the carcinogenic PAHs. The hazard index for the average exposure scenario was less than one. Exposure to

TABLE 6-14

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY YOUNG ADULTS TRESPASSING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE 45 kg YOUNG ADULT, PRORATED OVER 70-YEAR LIFETIME (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	4.07E-01	9.35E+00	1.59E-09	3.69E-07	2.55E-10	2.43E-07	1.85E-09	6.12E-07	8.40E-03	1.6E-11	5.1E-09
Chlordane	6.81E-02	2.30E+01	2.67E-10	9.07E-07	4.26E-11	5.99E-07	3.09E-10	1.51E-06	1.30E+00	4.0E-10	2.0E-06
4,4'-DDT	4.15E-02	1.02E+00	1.62E-10	4.02E-08	2.60E-11	2.66E-08	1.88E-10	6.68E-08	3.40E-01	6.4E-11	2.3E-08
Methylene chloride	2.21E-02	6.70E-01	5.77E-10	5.87E-08	4.61E-11	1.74E-08	6.23E-10	7.62E-08	7.50E-03	4.7E-12	5.7E-10
cPAHs (a)	1.10E+00	6.09E+00	4.31E-09	2.40E-07	6.89E-10	1.59E-07	4.99E-09	3.99E-07	1.15E+01	5.7E-08	4.6E-06
PCBs (b)	3.86E-01	1.30E+02	1.51E-09	5.13E-06	2.42E-10	3.39E-06	1.75E-09	8.52E-06	7.70E+00	1.3E-08	6.6E-05
Tetrachloroethene	7.44E-03	2.00E+00	1.94E-10	1.75E-07	1.55E-11	5.21E-08	2.10E-10	2.27E-07	5.10E-02	1.1E-11	1.2E-08
Trichloroethene	8.18E-02	1.20E+01	2.13E-09	1.05E-06	1.71E-10	3.11E-07	2.31E-09	1.36E-06	1.10E-02	2.5E-11	1.5E-08
TOTAL										7E-08	7E-05

(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Polychlorinated biphenyls.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(d) Noncarcinogenic polynuclear aromatic hydrocarbons.
NQ = Not quantified; dermal absorption of inorganics is negligible.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-14 (Continued)

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY YOUNG ADULTS TRESPASSING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

B. POTENTIAL NONCARCINOGENIC RISKS (c)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE (CDI) 45 kg YOUNG ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Acetone	8.14E-02	1.20E+00	2.48E-08	1.23E-06	2.68E-06	3.65E-07	2.70E-06	1.59E-06	1.00E-01	2.7E-05	1.6E-05
Bis(2-ethylhexyl)phthalate	4.07E-01	9.35E+00	1.86E-08	4.30E-06	2.97E-09	2.84E-06	2.16E-08	7.14E-06	2.00E-02	1.1E-06	3.6E-04
Cadmium	7.20E-01	2.72E+01	2.19E-07	2.78E-05	NQ	NQ	2.19E-07	2.78E-05	5.00E-04	4.4E-04	5.6E-02
Chlordane	6.81E-02	2.30E+01	3.11E-09	1.06E-05	4.98E-10	6.99E-06	3.61E-09	1.76E-05	5.00E-05	7.2E-05	3.5E-01
Chromium	4.55E+01	3.06E+03	1.39E-05	3.13E-03	NQ	NQ	1.39E-05	3.13E-03	5.00E-03	2.8E-03	6.3E-01
4,4'-DDT	4.15E-02	1.02E+00	1.89E-09	4.69E-07	3.03E-10	3.10E-07	2.20E-09	7.79E-07	5.00E-04	4.4E-06	1.6E-03
trans-1,2-Dichloroethene	4.07E-03	8.90E-02	1.24E-09	9.10E-08	1.34E-07	2.70E-08	1.35E-07	1.18E-07	1.00E-02	1.4E-05	1.2E-05
Lead	3.10E+01	6.83E+02	9.44E-06	6.99E-04	NQ	NQ	9.44E-06	6.99E-04	6.00E-04	1.6E-02	1.2E+00
Methylene chloride	2.21E-02	6.70E-01	6.73E-09	6.85E-07	7.27E-07	2.04E-07	7.33E-07	8.89E-07	6.00E-02	1.2E-05	1.5E-05
nPAHs (d)	7.13E-01	3.83E+00	3.26E-08	1.76E-06	5.21E-09	1.16E-06	3.78E-08	2.93E-06	4.10E-01	9.2E-08	7.1E-06
Tetrachloroethene	7.44E-03	2.00E+00	2.26E-09	2.05E-06	2.45E-07	6.08E-07	2.47E-07	2.65E-06	2.00E-02	1.2E-05	1.3E-04
Toluene	6.21E-03	4.96E-02	1.89E-09	5.07E-08	2.04E-07	1.51E-08	2.06E-07	6.58E-08	3.00E-01	6.9E-07	2.2E-07
HAZARD INDEX										<1 (0.02)	>1 (2)

(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Polychlorinated biphenyls.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(d) Noncarcinogenic polynuclear aromatic hydrocarbons.
NQ = Not quantified; dermal absorption of inorganics is negligible.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-15

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF NORTHERN SLUDGES BY YOUNG ADULTS TRESPASING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	3.70E+01	--	1.46E-06	--	9.63E-07	--	2.42E-06	8.40E-03	--	2.0E-08
Chlordane	6.62E+00	8.10E+01	2.59E-08	3.20E-06	4.14E-09	2.11E-06	3.00E-08	5.30E-06	1.30E+00	3.9E-08	6.9E-06
Chloroform	NA	3.15E+00	--	2.76E-07	--	8.20E-08	--	3.58E-07	8.10E-02	--	2.9E-08
4,4'-DDT	NA	1.97E+01	--	7.77E-07	--	5.13E-07	--	1.29E-06	3.40E-01	--	4.4E-07
cPAHs (a)	1.46E+01	5.92E+01	5.71E-08	2.34E-06	9.14E-09	1.54E-06	6.63E-08	3.88E-06	1.15E+01	7.6E-07	4.5E-05
TOTAL										8E-07	5E-05

NA = Not applicable; geometric mean not calculated with only one positive detection.
NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-15 (Continued)

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF NORTHERN SLUDGES BY YOUNG ADULTS TRESPASING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

B. POTENTIAL NONCARCINOGENIC RISKS (c)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	3.70E+01	--	1.70E-05	--	1.12E-05	--	2.83E-05	2.00E-02	--	1.41E-03
Cadmium	3.46E+00	1.30E+01	1.05E-06	1.33E-05	NQ	NQ	1.05E-06	1.33E-05	5.00E-04	2.11E-03	2.66E-02
Chlordane	6.62E+00	8.10E+01	3.02E-07	3.73E-05	4.83E-08	2.46E-05	3.50E-07	6.19E-05	5.00E-05	7.01E-03	1.24E+00
Chloroform	NA	3.15E+00	--	3.22E-06	--	9.57E-07	--	4.18E-06	1.00E-02	--	4.18E-04
Chromium	2.70E+02	8.02E+02	8.22E-05	8.20E-04	NQ	NQ	8.22E-05	8.20E-04	5.00E-03	1.64E-02	1.64E-01
4,4'-DDT	NA	1.97E+01	--	9.07E-06	--	5.98E-06	--	1.51E-05	5.00E-04	--	3.01E-02
Lead	8.19E+02	6.18E+03	2.49E-04	6.32E-03	NQ	NQ	2.49E-04	6.32E-03	6.00E-04	4.16E-01	1.05E+01
nPAHs (b)	2.59E+02	9.66E+02	1.18E-05	4.45E-04	1.89E-06	2.93E-04	1.37E-05	7.38E-04	4.10E-01	3.35E-05	1.80E-03
Pentachlorophenol	NA	6.40E+00	--	6.55E-06	--	1.94E-06	--	8.49E-06	3.00E-02	--	2.83E-04
Phenol	NA	9.80E+00	--	1.00E-05	--	2.98E-06	--	1.30E-05	4.00E-02	--	3.25E-04
Xylenes	NA	6.10E+01	--	6.24E-05	--	1.85E-05	--	8.09E-05	2.00E+00	--	4.05E-05
HAZARD INDEX										<1 (0.4)	>1 (12)

NA = Not applicable; geometric mean not calculated with only one positive detection.
NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-16

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SOUTHERN SLUDGES BY YOUNG ADULTS TRESPASING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.26E+00	1.50E+02	4.93E-09	5.92E-06	7.89E-10	3.91E-06	5.72E-09	9.82E-06	8.40E-03	4.8E-11	8.3E-08
Chlordane	NA	2.00E+01	--	7.89E-07	--	5.21E-07	--	1.31E-06	1.30E+00	--	1.7E-06
4,4'-DDT	1.28E-01	3.21E+02	5.01E-10	1.27E-05	8.02E-11	8.36E-06	5.81E-10	2.10E-05	3.40E-01	2.0E-10	7.1E-06
cPAHs (a)	4.18E+00	9.20E+00	1.64E-08	3.63E-07	2.62E-09	2.40E-07	1.90E-08	6.03E-07	1.15E+01	2.2E-07	6.9E-06
Tetrachloroethene	NA	8.60E+01	--	7.54E-06	--	2.24E-06	--	9.78E-06	5.10E-02	--	5.0E-07
Trichloroethene	1.33E-02	1.50E+01	3.47E-10	1.32E-06	3.46E-10	3.91E-07	6.93E-10	1.71E-06	1.10E-02	7.6E-12	1.9E-08
TOTAL										2E-07	2E-05

NA = Not applicable; geometric mean not calculated with only one positive detection.
NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-16 (Continued)

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SOUTHERN SLUDGES BY YOUNG ADULTS TRESPASING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

B. POTENTIAL NONCARCINOGENIC RISKS (c)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.26E+00	1.50E+02	5.75E-08	6.90E-05	9.21E-09	4.56E-05	6.67E-08	1.15E-04	2.00E-02	3.34E-06	5.73E-03
Cadmium	6.60E-01	1.80E+01	2.01E-07	1.84E-05	NQ	NQ	2.01E-07	1.84E-05	5.00E-04	4.02E-04	3.68E-02
Chlordane	NA	2.00E+01	--	9.21E-06	--	6.08E-06	--	1.53E-05	5.00E-05	--	3.06E-01
Chromium	4.16E+01	4.10E+02	1.27E-05	4.19E-04	NQ	NQ	1.27E-05	4.19E-04	5.00E-03	2.53E-03	8.39E-02
4,4'-DDT	1.28E-01	3.21E+02	5.84E-09	1.48E-04	9.35E-10	9.75E-05	6.78E-09	2.45E-04	5.00E-04	1.36E-05	4.91E-01
trans-1,2-Dichloroethene	NA	1.20E-01	--	1.23E-07	--	3.65E-08	--	1.59E-07	1.00E-02	--	1.59E-05
Lead	6.38E+02	1.00E+04	1.94E-04	1.02E-02	NQ	NQ	1.94E-04	1.02E-02	6.00E-04	3.24E-01	1.70E+01
nPAHs (b)	6.05E+00	3.80E+01	2.76E-07	1.75E-05	4.42E-08	1.15E-05	3.20E-07	2.90E-05	4.10E-01	7.82E-07	7.08E-05
Pentachlorophenol	NA	1.10E+02	--	1.13E-04	--	3.34E-05	--	1.46E-04	3.00E-02	--	4.86E-03
Tetrachloroethene	NA	8.60E+01	--	8.80E-05	--	2.61E-05	--	1.14E-04	2.00E-02	--	5.70E-03
Toluene	NA	1.50E+00	--	1.53E-06	--	4.56E-07	--	1.99E-06	3.00E-01	--	6.63E-06
1,1,1-Trichloroethane	NA	1.10E+01	--	1.13E-05	--	3.34E-06	--	1.46E-05	9.00E-02	--	1.62E-04
HAZARD INDEX										<1 (0.3)	>1 (18)

NA = Not applicable; geometric mean not calculated with only one positive detection.
NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

compounds exhibiting noncarcinogenic effects under plausible maximum conditions resulted in a hazard index greater than one, primarily due to the presence of lead which had an individual CDI:RfD ratio of 10. The CDI:RfD ratio for chlordane also exceeded one (1.2). Exposure to these two chemicals is not additive since their toxic endpoints (central nervous system for lead and liver for chlordane) are not the same.

For the Southern sludges, the upper bound excess lifetime cancer risk was $2x10^{-7}$ (two in ten million) for the average case and $2x10^{-5}$ (two in one hundred thousand) for the plausible maximum case. The latter risk was due primarily to the presence of 4,4'-DDT, carcinogenic PAHs, and chlordane. Under conditions of the average case, exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability of adverse health effects since the ratios of CDI:RfD are below one. However, under the plausible maximum scenario, the hazard index exceeds one primarily because of exposure to lead. A hazard index greater than one suggests that exposure may be associated with adverse health effects.

Inhalation of Contaminated Air. Young adults who use the Wildwood Conservation Corporation property for recreational purposes can be exposed via inhalation to contaminated air. Exposure to air contaminants may occur through inhalation of chemicals volatilized from soil or through inhalation of vehicle-generated dust. The approaches used to derive the air concentrations are summarized in Appendix C. The estimated air concentrations presented in Table 6-9 are used to derive exposure intake estimates and subsequently risk.

It should be noted that these air concentrations may overestimate exposure due to the fact that exposure is most likely to occur during the summer and fall when the area is heavily vegetated. The presence of vegetation would act to hinder dust generation and the release of volatiles.

The chronic daily intakes (CDIs) of inhaled airborne contaminants by young adults were derived using the assumed frequencies and durations listed in Table 6-17, a respiration rate of 2.8 m^3/hr (based on moderate activity rate reported by EPA (1987a)) and a body weight of 45 kg. In the absence of

TABLE 6-17

ASSUMPTIONS FOR USE IN THE RISK ASSESSMENT FOR INHALATION OF CONTAMINATED AIR AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

Parameter	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 days/year	168 days/year
Duration of Exposure	6 years	6 years
Inhalation Rate	2.8 m^3/hr	2.8 m^3/hr
Length of Visit	1 hour	2 hours
Average Weight Over Period of Exposure	45 kg	45 kg
Average Lifetime	70 years	70 years

definitive toxicokinetic data, 100% absorption of inhaled contaminants was assumed. For chemicals considered to be potentially carcinogenic by inhalation, the total cumulative exposure of 6 years was prorated over a 70 year lifetime to derive an average daily intake in mg/kg/day. For chemicals which may cause noncarcinogenic effects by inhalation, the average daily exposure over 6 years was calculated. Standard EPA assumptions for body weight were used.

Tables 6-18, 6-19, and 6-20 present the average and plausible maximum CDIs for the young adults exposed to contaminated air released from the surface soils, northern sludges, and southern sludges, respectively, associated with the Wildwood Conservation Corporation property. The risks associated with these exposure levels are also presented.

The upper bound excess lifetime cancer risk under this scenario for exposure to contaminated air originating from the surface soil, as seen in Table 6-18, is $1x10^{-7}$ (i.e., one in ten million) for the average case and $3x10^{-5}$ (i.e., three in one hundred thousand) for the plausible maximum case. The individual CDI:RfD ratios and the hazard indices for the chemicals exhibiting noncarcinogenic effects are below one for the average case. The hazard index for the maximum exposure scenario is equal to one.

For the northern sludge samples, the upper bound excess cancer risk for exposure to contaminated air for the average exposure case is $5x10^{-7}$ (i.e., five in ten million) and for the plausible maximum exposure case is $3x10^{-5}$ (i.e., three in one hundred thousand). Exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability of adverse health effects since the hazard indices are below one for the average and plausible maximum exposure scenarios.

The upper bound excess cancer risks for exposure to contaminated air originating in the southern sludges, Table 6-20, are $7x10^{-8}$ (seven in one hundred million) for the average case and $3x10^{-6}$ (i.e., three in one million) for the plausible maximum case. Exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability

TABLE 6-18

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINANTS RELEASED FROM SURFACE SOILS BY YOUNG ADULTS TRESPASSING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE 45-kg YOUNG ADULT PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.13E-08	2.59E-07	1.65E-11	1.21E-09	8.40E-03	1.4E-13	1.0E-11
Cadmium	1.95E-08	7.35E-07	2.84E-11	3.44E-09	6.10E+00	1.7E-10	2.1E-08
Chlordane	2.27E-06	7.69E-04	3.32E-09	3.59E-06	1.30E+00	4.3E-09	4.7E-06
Chromium	1.23E-06	8.27E-05	1.80E-09	3.87E-07	4.10E+01	7.4E-08	1.6E-05
4,4'-DDT	1.56E-08	3.85E-07	2.28E-11	1.80E-09	3.40E-01	7.8E-12	6.1E-10
Methylene chloride	2.08E-03	6.30E-02	3.04E-06	2.95E-04	1.40E-02	4.3E-08	4.1E-06
cPAHs (a)	2.98E-08	1.65E-07	4.35E-11	7.71E-10	6.11E+00	2.7E-10	4.7E-09
PCBs (b)	1.62E-07	5.47E-05	2.37E-10	2.56E-07	7.70E+00	1.8E-09	2.0E-06
Tetrachloroethene	1.29E-04	3.47E-02	1.88E-07	1.62E-04	3.30E-03	6.2E-10	5.4E-07
Trichloroethene	1.74E-03	2.55E-01	2.54E-06	1.19E-03	4.50E-03	1.1E-08	5.4E-06
TOTAL						1E-07	3E-05

B. POTENTIAL NONCARCINOGENIC RISKS (c)

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (CDI), 45-kg YOUNG ADULT (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Acetone	5.79E-04	8.54E-03	9.87E-06	4.66E-04	3.00E+00	3.29E-06	1.55E-04
Bis(2-ethylhexyl)phthalate	1.13E-08	2.59E-07	1.92E-10	1.41E-08	2.00E-02	9.61E-09	7.06E-07
Chlordane	2.27E-06	7.69E-04	3.87E-08	4.19E-05	5.00E-05	7.75E-04	8.39E-01
4,4'-DDT	1.56E-08	3.85E-07	2.66E-10	2.10E-08	5.00E-04	5.33E-07	4.20E-05
trans-1,2-Dichloroethene	1.68E-04	3.67E-03	2.86E-06	2.00E-04	1.00E-02	2.86E-04	2.00E-02
Lead	8.38E-07	1.85E-05	1.43E-08	1.01E-06	6.00E-04	2.38E-05	1.68E-03
Methylene chloride	2.08E-03	6.30E-02	3.55E-05	3.44E-03	6.00E-02	5.91E-04	5.73E-02
nPAHs (d)	1.06E-04	5.71E-04	1.81E-06	3.12E-05	4.10E-01	4.41E-06	7.60E-05
Tetrachloroethene	1.29E-04	3.47E-02	2.20E-06	1.89E-03	2.00E-02	1.10E-04	9.46E-02
Toluene	3.97E-05	3.17E-04	6.77E-07	1.73E-05	1.50E+00	4.51E-07	1.15E-05
HAZARD INDEX						<1 (0.002)	1

(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Polychlorinated biphenyls.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(d) Noncarcinogenic polynuclear aromatic hydrocarbons.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-19

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINATED AIR RELEASED FROM NORTHERN SLUDGES BY YOUNG ADULTS TRESPASSING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) AVERAGE	CONCENTRATION IN AIR (mg/m3) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE 45 kg YOUNG ADULT, PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	1.00E-06	--	4.92E-09	8.40E-03	--	4.1E-11
Cadmium	9.36E-08	3.52E-07	1.37E-10	1.73E-09	6.10E+00	8.3E-10	1.1E-08
Chlordane	9.64E-06	1.18E-04	1.41E-08	5.80E-07	1.30E+00	1.8E-08	7.5E-07
Chloroform	NA	5.43E-02	--	2.67E-04	8.10E-02	--	2.2E-05
Chromium	7.30E-06	2.17E-05	1.07E-08	1.06E-07	4.10E+01	4.4E-07	4.4E-06
4,4'-DDT	NA	8.28E-07	--	4.06E-09	3.40E-01	--	1.4E-09
cPAHs (a)	3.95E-07	1.60E-06	5.77E-10	7.86E-09	6.11E+00	3.5E-09	4.8E-08
TOTAL						5E-07	3E-05

B. POTENTIAL NONCARCINOGENIC RISKS (b)

COMPOUND	CONCENTRATION IN AIR (mg/m3) AVERAGE	CONCENTRATION IN AIR (mg/m3) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE (CDI) 45 kg YOUNG ADULT (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	1.00E-06	--	5.74E-08	2.00E-02	--	2.9E-06
Chlordane	9.64E-06	1.18E-04	1.64E-07	6.77E-06	5.00E-05	3.3E-03	1.4E-01
Chloroform	NA	5.43E-02	--	3.11E-03	1.00E-02	--	3.1E-01
4,4'-DDT	NA	8.28E-07	--	4.74E-08	5.00E-04	--	9.5E-05
Lead	2.21E-05	1.67E-04	3.78E-07	9.57E-06	6.00E-04	6.3E-04	1.6E-02
nPAHs (c)	1.66E-03	6.19E-03	2.82E-05	3.54E-04	4.10E-01	6.9E-05	8.6E-04
Pentachlorophenol	NA	1.76E-07	--	1.01E-08	3.00E-02	--	3.4E-07
Phenol	NA	4.70E-06	--	2.69E-07	2.00E-02	--	1.3E-05
Xylenes	NA	2.03E-02	--	1.16E-03	4.00E-01	--	2.9E-03
HAZARD INDEX						<1 (0.004)	<1 (0.5)

(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.
NA = Not applicable; average concentration not calculated with only one positive detection.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left

TABLE 6-20

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINATED AIR RELEASED FROM SOUTHERN SLUDGES BY YOUNG ADULTS TRESPASING AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) AVERAGE	CONCENTRATION IN AIR (mg/m3) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE 45-kg YOUNG ADULT, PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	3.42E-08	4.07E-06	4.99E-11	9.51E-09	8.40E-03	4.2E-13	8.0E-11
Cadmium	1.89E-08	4.87E-07	2.77E-11	1.14E-09	6.10E+00	1.7E-10	6.9E-09
Chlordane	NA	8.84E-05	--	2.07E-07	1.30E+00	--	2.7E-07
Chromium	1.12E-06	1.11E-05	1.64E-09	2.59E-08	4.10E+01	6.7E-08	1.1E-06
4,4'-DDT	2.33E-08	2.35E-05	3.41E-11	5.48E-08	3.40E-01	1.2E-11	1.9E-08
cPAHs (a)	6.10E-08	2.71E-07	8.91E-11	6.34E-10	6.11E+00	5.4E-10	3.9E-09
Tetrachloroethene	NA	1.96E-01	--	4.58E-04	3.30E-03	--	1.5E-06
Trichloroethene	3.72E-05	4.20E-02	5.44E-08	9.82E-05	4.60E-03	2.5E-10	4.5E-07
TOTAL						7E-08	3E-06

B. POTENTIAL NONCARCINOGENIC RISKS (b)

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (CDI), 45-kg YOUNG ADULT (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	3.42E-08	4.07E-06	5.83E-10	1.11E-07	2.00E-02	2.91E-08	5.55E-06
Chlordane	NA	8.84E-05	--	2.41E-06	5.00E-05	--	4.82E-02
4,4'-DDT	2.33E-08	2.35E-05	3.97E-10	6.40E-07	5.00E-04	7.95E-07	1.28E-03
trans-1,2-Dichloroethene	NA	6.50E-04	--	1.77E-05	1.00E-02	--	1.77E-03
Lead	1.73E-05	2.70E-04	2.94E-07	7.38E-06	6.00E-04	4.90E-04	1.23E-02
nPAHs (c)	1.19E-04	7.46E-04	2.03E-06	2.03E-05	4.10E-01	4.95E-06	4.96E-05
Pentachlorophenol	NA	3.13E-06	--	8.53E-08	3.00E-02	--	2.84E-06
Tetrachloroethene	NA	1.96E-01	--	5.35E-03	2.00E-02	--	2.67E-01
Toluene	NA	1.26E-03	--	3.44E-05	1.50E+00	--	2.29E-05
1,1,1-Trichloroethane	NA	7.88E-02	--	2.15E-03	3.00E-01	--	7.16E-03
HAZARD INDEX						<1 (0.0005)	<1 (0.3)

NA = Not applicable; geometric mean not calculated with only one positive detection.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

of adverse health effects since the hazard indices are below one for both the average and plausible maximum exposure scenarios.

6.3.2.2 Property Under Future-Use Conditions

In the absence of institutional controls limiting access of future uses of the Wildwood Conservation Corporation property, there are additional exposure pathways that must be evaluated. It is possible that in the future, construction activities or excavations for utilities would create the potential for workers to be exposed to contaminated soils through dermal contact and subsequent incidental ingestion as well as through inhalation. This type of exposure would be short term compared with the scenario developed in Section 6.3.2.1 for young adults using the property for recreational purposes or the scenario developed below for future residents, and thus this short term exposure scenario will not be quantified.

Direct contact with contaminated soil - future residents. If the Wildwood Conservation Corporation property were redeveloped for residential purposes, the potential exists for residents living on the property to be exposed to contaminated soils and sludges during outdoor activities. Table 6-21 summarizes the average and plausible maximum exposure assumptions used in this evaluation. These assumptions are derived from the same sources as mentioned above for the current-use direct contact scenario, but differ in that they are average lifetime exposures. Time-weighted averages for the amount of soil ingested per exposure event, the dermal soil contact rate, and an individual's body weight were calculated and used to quantitatively evaluate exposure of onsite residents over a lifetime.

Using these assumptions, chronic daily intake (CDI) estimates for incidental soil ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Appendix C of this endangerment assessment. The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption.

TABLE 6-21

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT BY FUTURE RESIDENTS WITH SOIL AND SLUDGES AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 day/yr	168 day/yr
Duration of Exposure	70 yr	70 yr
Average Weight[a]	70 kg	70 kg
Incidental Ingestion Rate[a]	54 mg/day	145 mg/day
Percent Phthalates, PAHs, PCBs, Pesticides Absorbed from Ingested Soils	15%	45%
Percent Other Organic Compounds Absorbed from Ingested Soils	100%	100%
Percent Inorganic Compounds Absorbed from Ingested Soils	100%	100%
Soil Contact Rate[a]	0.79 g/day	5.4 g/day
Percent Phthalates, PAHs, PCBs, Pesticides Absorbed Dermally from Skin	0.3%	3%
Percent Other Organic Compounds Absorbed Dermally from Skin	1%	10%
Percent Inorganic Compounds Absorbed Dermally from Skin	Negligible	Negligible
Average Lifetime	70 years	70 years

[a] Based on a lifetime average.

Table 6-22 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with the surface soil exposures. The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are $7x10^{-7}$ (i.e., seven in ten million) for the average exposure case and $2x10^{-3}$ (i.e., two in one thousand) for the plausible maximum exposure case. Under the conditions of the average case, exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability of adverse health effects since the ratio of the CDI:RfDs are below one. The hazard index for the plausible maximum case exceeds one, primarily due to exposure to lead whose CDI:RfD ratio exceeds one, suggesting that exposure may be associated with adverse health effects.

The average and plausible maximum CDIs and the potential carcinogenic and noncarcinogenic risks associated with exposure to the northern sludges are summarized in Table 6-23. The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are $8x10^{-6}$ (i.e., eight in one million) for the average exposure case and $1x10^{-3}$ (i.e., one in one thousand) for the plausible maximum exposure case. Exposure to the compounds exhibiting noncarcinogenic effects appear to present a low probability of adverse health effects since the hazard index is below one for the average case. For the plausible maximum case, the CDI:RfD ratio is greater than one for chlordane and lead and hence the hazard index is greater than one. It should be noted that exposure to these two chemicals will result in different toxic endpoints. Exposure to lead will affect the central nervous system (EPA 1986g) while exposure to chlordane will affect the liver (Ambrose et al. 1953).

For the southern sludges, the upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are $2x10^{-6}$ (i.e., two in one million) and $4x10^{-4}$ (i.e., four in ten thousand) for the average and plausible maximum cases, respectively, as seen in Table 6-24. Under the conditions of the average case, exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability of adverse health effects since the ratios of CDI:RfD are below

TABLE 6-22

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	4.07E-01	9.35E+00	1.43E-08	4.46E-06	4.19E-09	1.11E-05	1.85E-08	1.55E-05	8.40E-03	1.6E-10	1.3E-07
Chlordane	6.81E-02	2.30E+01	2.40E-09	1.10E-05	7.02E-10	2.72E-05	3.10E-09	3.82E-05	1.30E+00	4.0E-09	5.0E-05
4,4'-DDT	4.15E-02	1.02E+00	1.46E-09	4.86E-07	4.28E-10	1.21E-06	1.89E-09	1.69E-06	3.40E-01	6.4E-10	5.8E-07
Methylene chloride	2.21E-02	6.70E-01	5.19E-09	7.10E-07	2.30E-08	2.64E-06	2.82E-08	3.35E-06	7.50E-03	2.1E-10	2.5E-08
cPAHs (a)	1.10E+00	6.09E+00	3.87E-08	2.90E-06	1.13E-08	7.21E-06	5.00E-08	1.01E-05	1.15E+01	5.7E-07	1.2E-04
PCBs (b)	3.86E-01	1.30E+02	1.36E-08	6.20E-05	3.98E-09	1.54E-04	1.76E-08	2.16E-04	7.70E+00	1.4E-07	1.7E-03
Tetrachloroethene	7.44E-03	2.00E+00	1.75E-09	2.12E-06	6.87E-08	7.89E-06	7.05E-08	1.00E-05	5.10E-02	3.6E-09	5.1E-07
Trichloroethene	8.18E-02	1.20E+01	1.92E-08	1.27E-05	4.11E-07	4.72E-05	4.30E-07	5.98E-05	1.10E-02	4.7E-09	6.6E-07
TOTAL										7E-07	2E-03

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Polychlorinated biphenyls.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(d) Noncarcinogenic polynuclear aromatic hydrocarbons.

TABLE 6-22 (Continued)

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

B. POTENTIAL NONCARCINOGENIC RISKS (c)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Acetone	8.14E-02	1.20E+00	1.91E-08	1.27E-06	2.80E-09	4.73E-06	2.19E-08	6.01E-06	1.00E-01	2.2E-07	6.0E-05
Bis(2-ethylhexyl)phthalate	4.07E-01	9.35E+00	1.43E-08	4.46E-06	4.19E-09	1.11E-05	1.85E-08	1.55E-05	2.00E-02	9.3E-07	7.8E-04
Cadmium	7.20E-01	2.72E+01	1.69E-07	2.88E-05	NQ	NQ	1.69E-07	2.88E-05	5.00E-04	3.4E-04	5.8E-02
Chlordane	6.81E-02	2.30E+01	2.40E-09	1.10E-05	7.02E-10	2.72E-05	3.10E-09	3.82E-05	5.00E-05	6.2E-05	7.6E-01
Chromium	4.55E+01	3.06E+03	1.07E-05	3.24E-03	NQ	NQ	1.07E-05	3.24E-03	5.00E-03	2.1E-03	6.5E-01
4,4'-DDT	4.15E-02	1.02E+00	1.46E-09	4.86E-07	4.28E-10	1.21E-06	1.89E-09	1.69E-06	5.00E-04	3.8E-06	3.4E-03
trans-1,2-Dichloroethene	4.07E-03	8.90E-02	9.56E-10	9.43E-08	1.40E-10	3.51E-07	1.10E-09	4.45E-07	1.00E-02	1.1E-07	4.5E-05
Lead	3.10E+01	6.83E+02	7.28E-06	7.24E-04	NQ	NQ	7.28E-06	7.24E-04	6.00E-04	1.2E-02	1.2E+00
Methylene chloride	2.21E-02	6.70E-01	5.19E-09	7.10E-07	7.59E-10	2.64E-06	5.95E-09	3.35E-06	6.00E-02	9.9E-08	5.6E-05
nPAHs (d)	7.13E-01	3.83E+00	2.51E-08	1.82E-06	7.35E-09	4.53E-06	3.25E-08	6.35E-06	4.10E-01	7.9E-08	1.5E-05
Tetrachloroethene	7.44E-03	2.00E+00	1.75E-09	2.12E-06	2.56E-10	7.89E-06	2.00E-09	1.00E-05	2.00E-02	1.0E-07	5.0E-04
Toluene	6.21E-03	4.96E-02	1.46E-09	5.25E-08	2.13E-10	1.96E-07	1.67E-09	2.48E-07	3.00E-01	5.6E-09	8.3E-07
HAZARD INDEX										<1 (0.01)	>1 (3)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Polychlorinated biphenyls.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(d) Noncarcinogenic polynuclear aromatic hydrocarbons.

TABLE 6-23

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF NORTHERN SLUDGES BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	3.70E+01	--	1.76E-05	--	4.38E-05	--	6.14E-05	8.40E-03	--	5.2E-07
Chlordane	6.62E+00	8.10E+01	2.33E-07	3.86E-05	6.82E-08	9.59E-05	3.01E-07	1.34E-04	1.30E+00	3.9E-07	1.7E-04
Chloroform	NA	3.15E+00	--	3.34E-06	--	1.24E-05	--	1.58E-05	8.10E-02	--	1.3E-06
4,4'-DDT	NA	1.97E+01	--	9.39E-06	--	2.33E-05	--	3.27E-05	3.40E-01	--	1.1E-05
cPAHs (a)	1.46E+01	5.92E+01	5.14E-07	2.82E-05	1.50E-07	7.01E-05	6.65E-07	9.83E-05	1.15E+01	7.6E-06	1.1E-03
TOTAL										8E-06	1E-03

(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-23 (Continued)

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF NORTHERN SLUDGES BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

B. POTENTIAL NONCARCINOGENIC RISKS (b)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	3.70E+01	--	1.76E-05	--	4.38E-05	--	6.14E-05	2.00E-02	--	3.1E-03
Cadmium	3.46E+00	1.30E+01	8.13E-07	1.38E-05	NQ	NQ	8.13E-07	1.38E-05	5.00E-04	1.6E-03	2.8E-02
Chlordane	6.62E+00	8.10E+01	2.33E-07	3.86E-05	6.82E-08	9.59E-05	3.01E-07	1.34E-04	5.00E-05	6.0E-03	2.7E+00
Chloroform	NA	3.15E+00	--	3.34E-06	--	1.24E-05	--	1.58E-05	1.00E-02	--	1.6E-03
Chromium	2.70E+02	8.02E+02	6.34E-05	8.50E-04	NQ	NQ	6.34E-05	8.50E-04	5.00E-03	1.3E-02	1.7E-01
4,4'-DDT	NA	1.97E+01	--	9.39E-06	--	2.33E-05	--	3.27E-05	5.00E-04	--	6.5E-02
Lead	8.19E+02	6.18E+03	1.92E-04	6.55E-03	NQ	NQ	1.92E-04	6.55E-03	6.00E-04	3.2E-01	1.1E+01
nPAHs (c)	2.59E+02	9.66E+02	9.12E-06	4.61E-04	2.67E-06	1.14E-03	1.18E-05	1.60E-03	4.10E-01	2.9E-05	3.9E-03
Pentachlorophenol	NA	6.40E+00	--	6.78E-06	--	2.52E-05	--	3.20E-05	3.00E-02	--	1.1E-03
Phenol	NA	9.80E+00	--	1.04E-05	--	3.87E-05	--	4.90E-05	4.00E-02	--	1.2E-03
Xylenes	NA	6.10E+01	--	6.46E-05	--	2.41E-04	--	3.05E-04	2.00E+00	--	1.5E-04
HAZARD INDEX										<1 (0.3)	>1 (14)

(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-24

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SOUTHERN SLUDGES BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, BASED ON A LIFETIME EXPOSURE (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.26E+00	1.50E+02	4.44E-08	7.15E-05	1.30E-08	1.78E-04	5.74E-08	2.49E-04	8.40E-03	4.8E-10	2.1E-06
Chlordane	NA	2.00E+01	--	9.53E-06	--	2.37E-05	--	3.32E-05	1.30E+00	--	4.3E-05
4,4'-DDT	1.28E-01	3.21E+02	4.51E-09	1.53E-04	1.32E-09	3.80E-04	5.83E-09	5.33E-04	3.40E-01	2.0E-09	1.8E-04
cPAHs (a)	4.18E+00	9.20E+00	1.47E-07	4.39E-06	4.31E-08	1.09E-05	1.90E-07	1.53E-05	1.15E+01	2.2E-06	1.8E-04
Tetrachloroethene	NA	8.60E+01	--	9.11E-05	--	1.02E-04	--	1.93E-04	5.10E-02	--	9.8E-06
Trichloroethene	1.33E-02	1.50E+01	3.12E-09	1.59E-05	4.57E-10	1.78E-05	3.58E-09	3.36E-05	1.10E-02	3.9E-11	3.7E-07
TOTAL										2E-06	4E-04

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

NA = Not applicable; geometric mean not calculated with only one positive detection.
NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

TABLE 6-24 (Continued)

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SOUTHERN SLUDGES BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

B. POTENTIAL NONCARCINOGENIC RISKS (b)

COMPOUND	SOIL CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE, (CDI) 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.26E+00	1.50E+02	4.44E-08	7.15E-05	1.30E-08	1.78E-04	5.74E-08	2.49E-04	2.00E-02	2.9E-06	1.2E-02
Cadmium	6.60E-01	1.80E+01	1.55E-07	1.91E-05	NQ	NQ	1.55E-07	1.91E-05	5.00E-04	3.1E-04	3.8E-02
Chlordane	NA	2.00E+01	--	9.53E-06	--	2.37E-05	--	3.32E-05	5.00E-05	--	6.6E-01
Chromium	4.16E+01	4.10E+02	9.77E-06	4.34E-04	NQ	NQ	9.77E-06	4.34E-04	5.00E-03	2.0E-03	8.7E-02
4,4'-DDT	1.28E-01	3.21E+02	4.51E-09	1.53E-04	1.32E-09	3.80E-04	5.83E-09	5.33E-04	5.00E-04	1.2E-05	1.1E+00
trans-1,2-Dichloroethene	NA	1.20E-01	--	1.27E-07	--	1.42E-07	--	2.69E-07	1.00E-02	--	2.7E-05
Lead	6.38E+02	1.00E+04	1.50E-04	1.06E-02	NQ	NQ	1.50E-04	1.06E-02	6.00E-04	2.5E-01	1.8E+01
nPAHs (c)	6.05E+00	3.80E+01	2.13E-07	1.81E-05	6.23E-08	4.50E-05	2.75E-07	6.31E-05	4.10E-01	6.7E-07	1.5E-04
Pentachlorophenol	NA	1.10E+02	--	1.17E-04	--	1.30E-04	--	2.47E-04	3.00E-02	--	8.2E-03
Tetrachloroethene	NA	8.60E+01	--	9.11E-05	--	1.02E-04	--	1.93E-04	2.00E-02	--	9.6E-03
Toluene	NA	1.50E+00	--	1.59E-06	--	1.78E-06	--	3.36E-06	3.00E-01	--	1.1E-05
1,1,1-Trichloroethane	NA	1.10E+01	--	1.17E-05	--	1.30E-05	--	2.47E-05	9.00E-02	--	2.7E-04
HAZARD INDEX										<1 (0.2)	>1 (20)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

NA = Not applicable; geometric mean not calculated with only one positive detection.
NQ = Not quantified; dermal absorption of inorganics is negligible.
(a) Carcinogenic polynuclear aromatic hydrocarbons.
(b) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.

one. However, under the plausible maximum scenario, the hazard index exceeds one; a hazard index greater than one suggest that exposure may be associated with adverse health effects. The CDI:RfD ratios of both lead and 4,4-DDT exceed one. The toxic endpoints of these two compounds are different since lead affects the central nervous system (EPA 1986g) and 4,4-DDT is a liver toxicant (NIOSH 1978). Thus, exposure to these two chemicals may not be additive.

Inhalation of Volatiles - future residents. In addition to direct contact with contaminated soil and sludges, residents could be exposed to chemicals volatilizing from the soils and sludges while they are outdoors. Table 6-25 summarizes the average and plausible maximum exposure assumptions used in this evaluation. A time-weighted (lifetime) average inhalation rate for moderate activity (EPA 1985c) was used to evaluate exposure. It should be noted that these are conservative assumptions since the concentrations detected in the soils are expected to decrease over time. This scenario also does not consider inhalation exposure of volatiles which could migrate from outdoors into the home. Thus, in terms of total potential exposure, this scenario may underestimate exposure and risk.

The average and plausible maximum CDIs and potential risks associated with exposure to surface soil via this pathway are summarized in Table 6-26. The potential lifetime upper bound excess cancer risk is $3x10^{-7}$ (i.e., three in ten million) for the average exposure case and $1x10^{-4}$ (i.e., one in ten thousand) for the plausible maximum case. Exposure to the noncarcinogenic compounds appears to represent a low probability of adverse health effects based on the conditions of average and plausible maximum exposure, since the hazard indices are less than one.

Table 6-27 presents the average and plausible maximum CDIs and the potential carcinogenic and noncarcinogenic risks associated with exposure to volatiles released from the northern sludges. The upper bound excess lifetime cancer risk for the average exposure case is $1x10^{-7}$ (i.e., one in ten million) and for the plausible maximum case is $2x10^{-4}$ (i.e., two in ten thousand). Under the conditions of both the average and plausible maximum cases, exposure to

TABLE 6-25

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR OUTDOOR INHALATION EXPOSURE BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	1 hr/day	3 hr/day
Duration of Exposure	100 d/yr	168 d/yr
Inhalation Rate[a]	2.1 m^3/hr	2.1 m^3/hr
Average Weight	70 kg	70 kg
Average Lifetime	70 yr	70 yr

[a] Based on a lifetime average.

TABLE 6-26

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINANTS RELEASED FROM SURFACE SOI
BY RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY (a)

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	2.70E-10	6.21E-09	2.23E-12	2.58E-10	8.40E-03	1.9E-14	2.2E-12
Chlordane	2.27E-06	7.68E-04	1.87E-08	3.19E-05	1.30E+00	2.4E-08	4.1E-05
4,4'-DDT	1.45E-08	3.57E-07	1.20E-10	1.48E-08	3.40E-01	4.1E-11	5.0E-09
Methylene chloride	2.08E-03	6.30E-02	1.71E-05	2.62E-03	1.40E-02	2.4E-07	3.7E-05
cPAHs (b)	5.35E-11	2.96E-10	4.41E-13	1.23E-11	6.11E+00	2.7E-12	7.5E-11
PCBs (c)	1.52E-07	5.12E-05	1.25E-09	2.13E-06	7.70E+00	9.6E-09	1.6E-05
Tetrachloroethene	1.29E-04	3.47E-02	1.06E-06	1.44E-03	3.30E-03	3.5E-09	4.8E-06
Trichloroethene	1.74E-03	2.55E-01	1.43E-05	1.06E-02	4.60E-03	6.6E-08	4.9E-05
TOTAL						3E-07	1E-04

B. POTENTIAL NONCARCINOGENIC RISKS (d)

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Acetone	5.79E-04	8.54E-03	4.77E-06	3.55E-04	3.00E+00	1.59E-06	1.18E-04
Bis(2-ethylhexyl)phthalate	2.70E-10	6.21E-09	2.23E-12	2.58E-10	2.00E-02	1.11E-10	1.29E-08
Chlordane	2.27E-06	7.68E-04	1.87E-08	3.19E-05	5.00E-05	3.74E-04	6.38E-01
4,4'-DDT	1.45E-08	3.57E-07	1.20E-10	1.48E-08	5.00E-04	2.39E-07	2.97E-05
trans-1,2-Dichloroethene	1.68E-04	3.67E-03	1.39E-06	1.53E-04	1.00E-02	1.39E-04	1.53E-02
Methylene chloride	2.08E-03	6.30E-02	1.71E-05	2.62E-03	6.00E-02	2.86E-04	4.36E-02
nPAHs (e)	1.06E-04	5.71E-04	8.74E-07	2.37E-05	4.10E-01	2.13E-06	5.79E-05
Tetrachloroethene	1.29E-04	3.47E-02	1.06E-06	1.44E-03	2.00E-02	5.32E-05	7.21E-02
Toluene	3.17E-05	3.17E-04	2.61E-07	1.32E-05	1.50E+00	1.74E-07	8.78E-06
HAZARD INDEX						<1 (0.0009)	<1 (0.8)

(a) Exposure to the inorganic chemicals of potential concern is not evaluated here because they are not volatile.
(b) Carcinogenic polynuclear aromatic hydrocarbons.
(c) Polychlorinated biphenyls.
(d) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(e) Noncarcinogenic polynuclear aromatic hydrocarbons.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the size of the

A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-27

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINATED AIR RELEASED FROM NORTHERN SLUDGES BY RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY (a)

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) AVERAGE	CONCENTRATION IN AIR (mg/m3) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	1.08E-09	--	4.48E-11	8.40E-03	--	3.8E-13
Chlordane	9.46E-06	1.16E-04	7.78E-08	4.81E-06	1.30E+00	1.0E-07	6.3E-06
Chloroform	NA	5.43E-02	--	2.25E-03	8.10E-02	--	1.8E-04
4,4'-DDT	NA	2.95E-07	--	1.22E-08	3.40E-01	--	4.2E-09
cPAHs (b)	3.00E-11	1.20E-10	2.47E-13	4.98E-12	6.11E+00	1.5E-12	3.0E-11
TOTAL						1E-07	2E-04

B. POTENTIAL NONCARCINOGENIC RISKS (c)

COMPOUND	CONCENTRATION IN AIR (mg/m3) AVERAGE	CONCENTRATION IN AIR (mg/m3) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	1.05E-04	--	4.36E-06	2.00E-02	--	2.2E-04
Chlordane	9.46E-06	1.16E-04	7.78E-08	4.81E-06	5.00E-05	1.6E-03	9.6E-02
Chloroform	NA	5.43E-02	--	2.25E-03	1.00E-02	--	2.3E-01
4,4'-DDT	NA	2.95E-07	--	1.22E-08	5.00E-04	--	2.4E-05
nPAHs (d)	1.65E-03	6.16E-03	1.36E-05	2.56E-04	4:10E-01	3.3E-05	6.2E-04
Pentachlorophenol	NA	2.91E-09	--	1.21E-10	3.00E-02	--	4.0E-09
Phenol	NA	4.44E-06	--	1.84E-07	2.00E-02	--	9.2E-06
Xylenes	NA	2.03E-02	--	8.42E-04	4.00E-01	--	2.1E-03
HAZARD INDEX						<1 (0.002)	<1 (0.3)

(a) Exposure to the inorganic chemicals of potential concern is not evaluated here because they are not volatile.
(b) Carcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(d) Noncarcinogenic polynuclear aromatic hydrocarbons.
NA = Not applicable; average concentration not calculated with only one positive detection.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability of adverse health effects since the hazard indices are below one.

For the southern sludges, the upper bound excess lifetime cancer risks associated with chemicals exhibiting potential carcinogenic effects are $1x10^{-9}$ (i.e., one in one billion) and $1x10^{-5}$ (i.e., one in one hundred thousand) for the average and plausible maximum cases, as seen in Table 6-28. Under the conditions of both the average and plausible maximum cases, exposure to the chemicals of potential concern exhibiting noncarcinogenic effects appear to present a low probability of adverse health effects since the hazard indices are below one.

Ingestion of Groundwater - future residents. Under this future-use scenario, it is assumed that there are no future remedial actions and institutional actions limiting access to the use of the groundwater. Hence, individuals could be exposed to groundwater contaminants by direct ingestion of tap water. The average individual is assumed to weigh 70 kg and drink 2 liters of water each day for 70 years (an average lifetime). Based on these assumptions, and the existing chemical concentrations in the groundwater, chronic daily intakes were derived and are presented in Table 6-29. The risks associated with these intake levels are also presented for chemicals potentially exhibiting carcinogenic and noncarcinogenic effects.

The upper bound lifetime excess cancer risks associated with ingestion of groundwater are $8x10^{-4}$ (i.e., eight in ten thousand) and $2x10^{-1}$ (i.e., two in ten) for the average and plausible maximum cases, respectively, primarily due to tetrachloroethene and trichloroethene. The hazard index for the average exposure scenario is less than one. Under the plausible maximum exposure scenario, the CDI:RfD ratios for the individual chemicals of potential concern are greater than one for all the chemicals of potential concern with the exception of 1,2-dichlorobenzene, manganese and total xylenes. The hazard index, as a result, exceeds one, primarily because of exposure to tetrachloroethene. A hazard index greater than one suggests that exposure may be associated with adverse health effects. Exposure to chloroform, trans-

TABLE 6-28

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF CONTAMINATED AIR RELEASED FROM SOUTHERN SLUDGES BY FUTURE RESIDENTS AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY (a)

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) AVERAGE	CONCENTRATION IN AIR (mg/m3) PLAUSIBLE MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.10E-10	1.21E-08	9.04E-13	1.59E-10	8.40E-03	7.6E-15	1.3E-12
Chlordane	NA	8.79E-05	--	1.16E-06	1.30E+00	--	1.5E-06
4,4'-DDT	5.89E-09	1.48E-05	4.84E-11	1.95E-07	3.40E-01	1.6E-11	6.6E-08
cPAHs (b)	3.00E-11	6.00E-11	2.47E-13	7.89E-13	6.11E+00	1.5E-12	4.8E-12
Tetrachloroethene	NA	1.96E-01	--	2.58E-03	3.30E-03	--	8.5E-06
Trichloroethene	3.72E-05	4.20E-02	3.06E-07	5.52E-04	4.60E-03	1.4E-09	2.5E-06
TOTAL						1E-09	1E-05

B. POTENTIAL NONCARCINOGENIC RISKS (c)

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	1.10E-10	1.21E-08	9.04E-13	1.59E-10	2.00E-02	4.52E-11	7.96E-09
Chlordane	NA	8.79E-05	--	1.16E-06	5.00E-05	--	2.31E-02
4,4'-DDT	5.89E-09	1.48E-05	4.84E-11	1.95E-07	5.00E-04	9.68E-08	3.89E-04
trans-1,2-Dichloroethene	NA	6.50E-04	--	8.55E-06	1.00E-02	--	8.55E-04
nPAHs (d)	1.19E-04	7.45E-04	9.78E-07	9.80E-06	4.10E-01	2.39E-06	2.39E-05
Pentachlorophenol	NA	1.54E-07	--	2.03E-09	3.00E-02	--	6.75E-08
Tetrachloroethene	NA	1.96E-01	--	2.58E-03	2.00E-02	--	1.29E-01
Toluene	NA	1.26E-03	--	1.66E-05	1.50E+00	--	1.10E-05
1,1,1-Trichloroethane	NA	7.88E-02	--	1.04E-03	3.00E-01	--	3.45E-03
HAZARD INDEX						<1 (2E-06)	<1 (0.2)

(a) Exposure to the inorganic chemicals of potential concern is not evaluated here because they are not volatile.
(b) Carcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(d) Noncarcinogenic polynuclear aromatic hydrocarbons.
NA = Not applicable; geometric mean not calculated with only one positive detection.
NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 6-29

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Chloroform	17.5	6000	5.00E-04	1.71E-01	8.10E-02	4.1E-05	1.4E-02
Tetrachloroethene	7.6	58000	2.17E-04	1.66E+00	5.10E-02	1.1E-05	8.1E-02
Trichloroethene	656	440000	1.87E-02	1.26E+01	1.10E-02	2.1E-04	1.3E-01
Vinyl chloride	7.5	300	2.14E-04	8.57E-03	2.30E+00	4.9E-04	2.0E-02
TOTAL	--	--	--	--	--	8E-04	2E-01

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Chloroform	17.5	6000	5.00E-04	1.71E-01	1.00E-02	5.0E-02	1.7E+01
1,2-Dichlorobenzene	7.0	160	2.00E-04	4.57E-03	8.90E-02	2.2E-03	5.1E-02
trans-1,2-Dichloroethene	10.0	4510	2.86E-04	1.29E-01	1.00E-02	2.9E-02	1.3E+01
Manganese	470	2200	1.34E-02	6.29E-02	2.20E-01	6.1E-02	2.9E-01
Tetrachloroethene	7.6	58000	2.17E-04	1.66E+00	2.00E-02	1.1E-02	8.3E+01
1,1,1-Trichloroethane	16.6	7800	4.74E-04	2.23E-01	9.00E-02	5.3E-03	2.5E+00
Xylenes, total	19.1	14000	5.46E-04	4.00E-01	2.00E+00	2.7E-04	2.0E-01
HAZARD INDEX	--	--	--	--	--	<1 (0.2)	>1 (116)

(a) Noncarcinogens and potential carcinogens with RfDs evaluated for noncarcinogenic risk.

NA = Not applicable; mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

1,2,-dichloroethene, tetrachloroethene, and 1,1,1-trichloroethane results in additive since these four chemicals all produce liver damage.

To determine whether or not there would be any adverse health effects from short-term exposure to the four chemicals of potential concern whose maximum concentrations exceed their chronic RfDs, a comparison was made between the detected concentration and short term health criteria. Only a chronic RfD is available for chloroform, so it will not be discussed further. The maximum concentration of trans-1,2-dichloroethene is below the one-day health advisory for children of 20,000 ug/liter but exceeds the 10-day health advisory for children of 1,430 ug/liter (EPA 1987h). The maximum concentration of tetrachloroethene exceeds both the one and 10-day health advisories for children which are both set at 2,000 ug/liter. The maximum concentration of 1,1,1-trichloroethane is below the one-day health advisory for children of 140,000 ug/liter and the 10-day health advisory for children of 35,000 ug/liter (EPA 1987j). Additionally, the maximum CDI is less than the oral subchronic RfD of 0.9 mg/kg/d (EPA 1988c).

Inhalation Of Contaminants While Showering. In addition to ingestion of groundwater, inhalation of volatilized contaminants can occur while using the water for nonconsumptive uses. The inorganic chemicals of potential concern for the groundwater pathway are not expected to volatilize. As a result, antimony, arsenic, barium, cadmium, and manganese are not evaluated for this scenario.

Exposure to individuals while showering is quantified here. The shower model of Foster and Chrostowski (1987), discussed in Appendix C, Section C.2, was used to quantify exposure via this pathway. The potential health risks associated with the estimated inhalation exposures while showering are presented in Table 6-30. It should be noted that while the chronic daily intake for exposure to volatile organic contaminants in groundwater via ingestion and inhalation are comparable, as expected in the literature (Foster and Chrostowski 1987, McKone 1987, EPA 1984i), the risks from this exposure will vary due to differences in the potency factors.

TABLE 6-30

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VAPORS WHILE SHOWERING WITH GROUNDWATER AT THE WILDWOOD CONSERVATION CORPORATION PROPERTY

A. POTENTIAL CARCINOGENIC EFFECTS

	CHRONIC DAILY INTAKE (mg/kg/d)			LIFETIME UPPER BOUND EXCESS CANCER RISK	
COMPOUND	AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	AVERAGE	PLAUSIBLE MAXIMUM
Chloroform	3.91E-04	1.52E-01	8.10E-02	3.2E-05	1.2E-02
Tetrachloroethene	1.77E-04	1.35E+00	3.30E-03	5.8E-07	4.5E-03
Trichloroethene	1.65E-02	1.11E+01	4.60E-03	7.6E-05	5.1E-02
Vinyl chloride	2.51E-04	1.01E-02	2.95E-01	7.4E-05	3.0E-03
TOTAL	--	--	--	2E-04	7E-02

B. NONCARCINOGENIC EFFECTS (a)

	CHRONIC DAILY INTAKE (CDI) (mg/kg/d)			RATIO OF CDI:RfD	
COMPOUND	AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	AVERAGE	PLAUSIBLE MAXIMUM
Chloroform	3.91E-04	1.52E-01	1.00E-02	3.9E-02	1.5E+01
1,2-Dichlorobenzene	1.54E-04	3.57E-03	8.90E-02	1.7E-03	4.0E-02
trans-1,2-Dichloroethene	2.80E-04	1.26E-01	1.00E-02	2.8E-02	1.3E+01
Tetrachloroethene	1.77E-04	1.35E+00	2.00E-02	8.9E-03	6.8E+01
1,1,1-Trichloroethane	4.21E-04	1.98E-01	3.00E-01	1.4E-03	6.6E-01
Xylenes, total	5.18E-04	3.79E-01	4.00E-01	1.3E-03	9.5E-01
HAZARD INDEX	--	--	--	<1 (0.08)	>1 (96)

(a) Noncarcinogens and potential carcinogens with RfDs evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

The excess lifetime upper bound cancer risks associated with the average and plausible maximum cases were $2x10^{-4}$ (i.e., two in ten thousand) and $7x10^{-2}$ (i.e., seven in one hundred), respectively. For chemicals exhibiting noncarcinogenic effects, the individual CDI:RfD ratios for each compound under the average conditions were below one as was the corresponding hazard index indicating a low probability of adverse health effects. The hazard index for the plausible maximum case was greater than one primarily due to exposure to tetrachloroethene, chloroform, and trans-1,2-dichloroethene. A hazard index greater than one suggests that exposure may be associated with adverse health effects. Exposure to these chemicals can be considered to be additive since their toxic endpoints are the same (i.e., each affects the liver).

6.3.3 MULTIMEDIA EXPOSURES

Exposure via one of the pathways discussed above for the future-use scenarios does not preclude exposures via other pathways. For example, residents of the area may be exposed to contaminated soil and contaminated tap water. However, exposure by one route generally dominates the exposure and risk calculations, and by adding exposures from other routes is unlikely to have a substantial effect on risks. For example, under the average future-use scenario, the upper bound excess lifetime cancer risk associated with direct contact with surface soil is $7x10^{-7}$ and with inhalation of volatiles released from the soil $9x10^{-8}$. The upper bound lifetime cancer risk associated with the inhalation of vapors released while showering is $2x10^{-4}$, and that associated with the ingestion of groundwater is $1x10^{-3}$. The sum of these four values is approximately equal to the risk value associated with ingestion of groundwater alone. Therefore, in this situation, the quantitative risk is determined by only one type of exposure.

6.4 SUMMARY OF WILDWOOD CONSERVATION CORPORATION PROPERTY EVALUATION

This section of the Endangerment Assessment for the Wildwood Conservation Corporation property is a baseline assessment, which evaluates potential impacts to human health in the absence of further remedial actions under both current- and future-use scenarios. Chemicals of potential concern were selected based on the sampling data of the environmental media and consideration of toxicity. Soil and sludge chemicals of potential concern were acetone, bis(2-ethylhexyl)phthalate, cadmium, chlordane, chloroform, chromium, 4,4'-DDT, trans-1,2-dichloroethene, lead, methylene chloride, carcinogenic PAHs, noncarcinogenic PAHs, PCBs, pentachlorophenol, phenol, tetrachloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, and xylene. The groundwater chemicals of potential concern were chloroform, trans-1,2-dichloroethene, 1,2-dichlorobenzene, manganese, tetrachloroethene, 1,1,1-trichloroethane, trichloroethene, vinyl chloride, and xylene.

Under current land-use conditions at the Wildwood Conservation Corporation property, the principal exposure pathway by which human receptors could potentially be exposed to site contaminants was direct contact with surface soils and sludges by young adults using the property for recreational uses and inhalation of contaminated air released from these same sources. Average and plausible maximum exposure scenarios were developed for this pathway. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed population. Human health risks were assessed based on these estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of young adults to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $7x10^{-8}$ for the average exposure case and $7x10^{-5}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of average exposure, as the hazard index is less than one. Under conditions of plausible maximum exposure, there is a probability of adverse health effects as the hazard index exceeds one.

- Exposure of young adults to northern sludges through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $8x10^{-7}$ for the average exposure case and $5x10^{-5}$ for the plausible maximum exposure case. Exposure of young adults to southern sludges through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $2x10^{-7}$ for the average exposure case and $2x10^{-5}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects for both the northern and southern sludges appears to present a low probability of adverse health effects based on the conditions of average exposure, as the hazard index is less than one. The hazard index exceeds one for plausible maximum exposure to either the northern or southern sludges.

- Exposure of young adults through the inhalation of dust and volatile organics generated from surface soils while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of $1x10^{-7}$ and $3x10^{-5}$ for the average and plausible maximum exposure cases, respectively. Exposure of young adults through the inhalation of dust and volatile organics generated from northern sludges while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of $5x10^{-7}$ and $3x10^{-5}$ for the average and plausible maximum exposure cases, respectively. Exposure of young adults through the inhalation of dust and volatile organics generated from southern sludges while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of $7x10^{-8}$ and $3x10^{-6}$ for the average and plausible maximum exposure cases, respectively. There appears to be a low probability of adverse health effects resulting from noncarcinogenic exposure to air contamination generated from surface soils, northern sludges, and southern sludges since the hazard indices are less than or equal to one for the average and plausible maximum exposure cases.

The exposure scenario described above would apply for future land-use conditions as well. In addition, exposure pathways related to residential soil exposure and to uses of the groundwater were considered. The groundwater uses included ingestion of groundwater and inhalation of volatile organic chemicals released while showering. Average and plausible maximum exposure scenarios were developed. The conclusions are as follows:

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of $7x10^{-7}$ for the average exposure case and $2x10^{-3}$ for the plausible maximum exposure case. The hazard indices for the average and plausible maximum cases were below one and slightly greater than one, respectively. For the northern sludges, the upper bound excess lifetime cancer risks from average and plausible maximum exposures were $8x10^{-6}$ and $1x10^{-3}$, respectively. The upper bound excess lifetime cancer risks from exposure to the southern sludges were $2x10^{-6}$ and $4x10^{-4}$ for the average and plausible maximum cases, respectively. For both the northern and southern sludges, under the conditions of the average case, the ratios of the CDI:RfD are below one and the hazard index is below one. However, under the plausible maximum scenarios, the hazard index exceeds one.

- Exposure of residents through the inhalation of volatile organic compounds released from surface soils could result in upper bound excess lifetime cancer risks of $3x10^{-7}$ and $1x10^{-4}$ under average and plausible maximum exposure conditions, respectively. The upper bound excess cancer risk from inhalation of volatiles released form the northern sludges are $1x10^{-7}$ for the average case and $2x10^{-4}$ for the plausible maximum case. For the southern sludges, the upper bound excess lifetime cancer risks for the average and plausible maximum cases are $1x10^{-9}$ and $1x10^{-5}$, respectively. The hazard indices for the soil and sludges under the average and plausible maximum cases are less than one.

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of $8x10^{-4}$ and $2x10^{-1}$ for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average case and exceeded 1 for the plausible maximum case.

- Inhalation of volatiles released from the groundwater while showering could result in $2x10^{-4}$ and $7x10^{-2}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average case and exceeded one for the plausible maximum case.

7.0 CENTRAL AREA OF THE WELLS G & H SITE

The central area of the Wells G & H site for the purposes of this report encompasses the area surrounding the wells themselves as well as the wetlands associated with the Aberjona river. For the purposes of this evaluation, any section of the site which is not part of one of the other properties will be discussed in this section of the endangerment assessment.

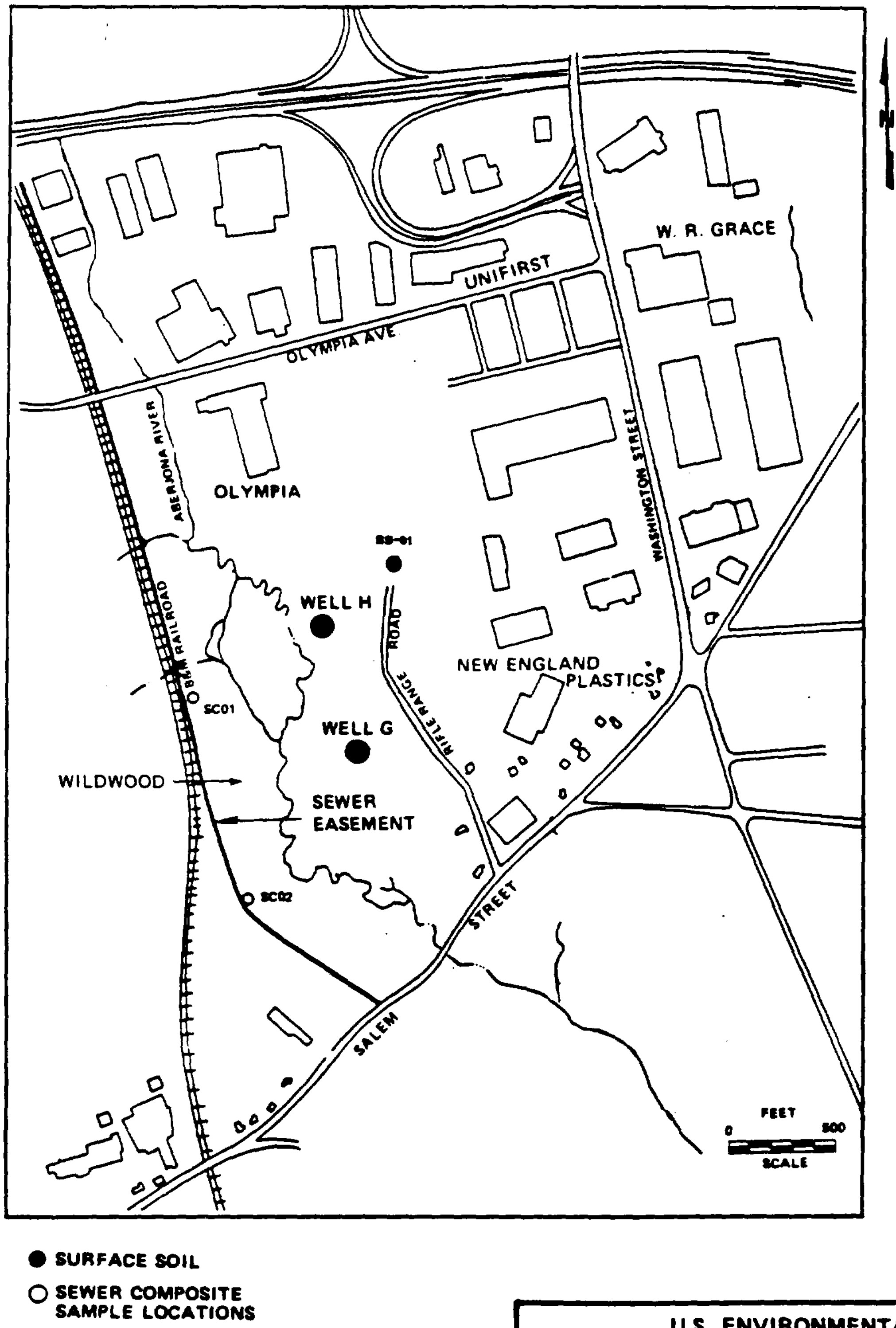
7.1 CHEMICALS OF POTENTIAL CONCERN

The basis for the selection of the chemicals of potential concern is outlined in Appendix A of this document and is based upon the methodology presented in the Superfund Public Health Evaluation Manual (EPA 1986a). The data used in this evaluation resulted from site investigations conducted by NUS (1986) and Ebasco (1988a) for U.S. EPA. The analytical chemistry data are tabulated in Appendix E of this document.

7.1.1 SOIL

One surface soil sample was collected by Ebasco (1988a) from what appeared to be a surface soil stain at the Rifle Range north of Well H (Figure 7-1). The sample was obtained to evaluate the extent of soil contamination at this spot. Table 7-1 summarizes the data. The two organic compounds detected in the soil were chlordane and pyrene. Both were selected as chemicals of potential concern. Pyrene, a noncarcinogenic PAH, may be present at this spot as a result of its presence in oil that may have leaked from a car. Since only one sample was taken, the presence of these compounds at this spot should not be construed as representative of conditions at the central area.

The inorganic constituents detected within the central area were within typical soil levels (i.e., the concentration was less than twice the maximum background concentration) (Table A-1, Appendix A) with the exception of cadmium and lead. Thus, these two inorganics will be selected as chemicals of potential concern for the central area.



U.S. ENVIRONMENTAL PROTECTION AGENCY

WELLS G & H

Figure 7-1

SEWER COMPOSITE AND CENTRAL AREA SURFACE SOIL SAMPLING LOCATIONS

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TABLE 7-1

COMPOUNDS DETECTED IN SURFACE SOILS AT THE CENTRAL AREA OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	DETECTED VALUE
ORGANICS (ug/kg)		
SEMI-VOLATILES		
PYRENE	1/1	2300
PESTICIDES/PCB'S		
CHLORDANE	1/1	530
INORGANICS (mg/kg)		
ALUMINUM	1/1	7020
ARSENIC	1/1	5.00
BARIUM	1/1	56.0
BERYLLIUM	1/1	0.50
CADMIUM	1/1	2.50
CALCIUM	1/1	3300
CHROMIUM	1/1	13.0
COPPER	1/1	29.0
IRON	1/1	8570
LEAD	1/1	161
MAGNESIUM	1/1	1600
MANGANESE	1/1	293
MERCURY	1/1	0.12
NICKEL	1/1	13.0
POTASSIUM	1/1	758
SODIUM	1/1	109
VANADIUM	1/1	24.0
ZINC	1/1	85.0

NA = Not applicable; mean not calculated with only one positive detection.

ND = Not detected.

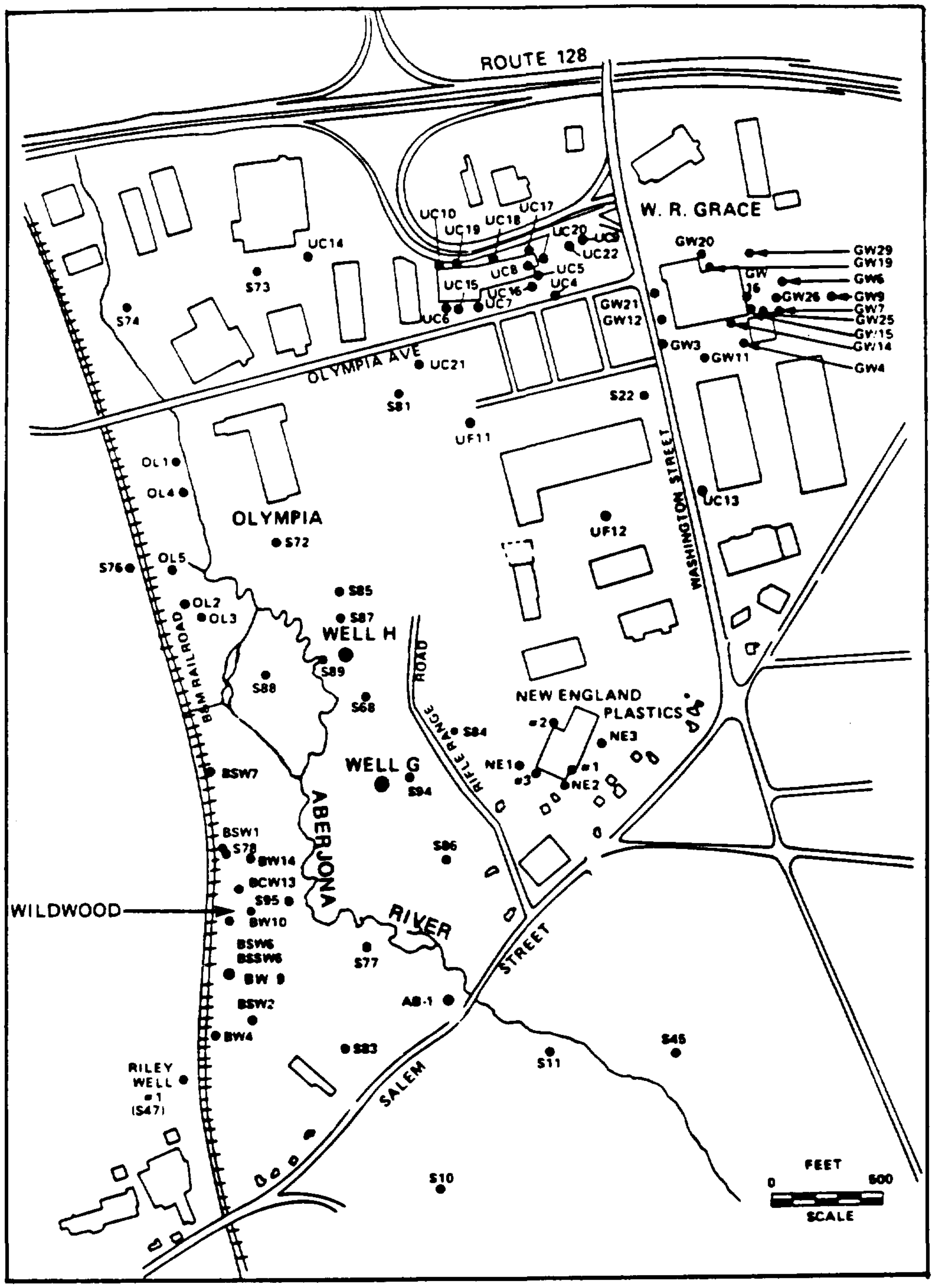
#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE A GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

7.1.2 GROUNDWATER

The 7 groundwater monitoring wells, S68, S83, S84, S85, S86, S87, and S89, shown in Figure 7-2, were selected to represent conditions at Wells G & H themselves and were used exclusively to select chemicals of potential concern. The number of wells was limited in order to focus on conditions at the two municipal wells. This provides information on the potability of any water that could potentially be drawn from the wells at some time in the future. It should be noted that when the municipal wells are used, these wells would draw from a larger area and it is difficult to predict water quality. However, a selection of wells around Wells G & H can be used to approximate risk. Both 1985 and 1987 data (NUS 1986, Ebasco 1988) were used. In those cases when the compound was detected in 1985 but not in 1987, the compound was not selected as a chemical of potential concern. It should be noted that the concentrations of inorganic constituents measured in groundwater may reflect total rather than dissolved concentrations since Ebasco (1988a) did not filter their samples and NUS (1986) may not have filtered their samples.

Fourteen organic compounds were detected in the central area groundwater as seen in Table 7-2. The most frequently detected were tetrachloroethene and trichloroethene. trans-1,2-Dichloroethene and 1,1,1-trichloroethane were the next most frequently detected compounds. These four organic chemicals were selected as chemicals of potential concern for the central area groundwater. Of the other compounds detected, most were detected in less than 5% of the samples and at low levels, generally below 5 ug/liter. Thus, none of these compounds were selected as chemicals of potential concern.

The inorganic constituents measured in the central area groundwater not considered to be chemicals of potential concern fell into three groups: for the most part they were either below typical groundwater levels (Table A-2, Appendix A), greater than the typical levels but were essential nutrients and were detected less than 10 times the typical level, or they were detected in 7-8% or less of the samples. (The 7-8% frequency cut off was used here because it represented a positive detection in only one sample.) Those



U.S. ENVIRONMENTAL PROTECTION AGENCY

WELLS G & H

Figure 7-2

SUPPLEMENTAL RI GROUNDWATER SAMPLING LOCATIONS AT THE WELLS G&H SITE

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TABLE 7-2
COMPOUNDS DETECTED IN GROUNDWATER FOR THE CENTRAL AREA
OF THE WELLS G & H SITE

COMPOUND	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/liter)			
BIS(2-ETHYLHEXYL) PHTHALATE	3/17	5.88	79.0
CHLOROBENZENE	1/33	NA	2.80
CHLOROFORM	1/1	NA	13.0
1,2-DICHLOROBENZENE	1/18	NA	5.00
1,1-DICHLOROETHANE	1/1	NA	2.00
1,1-DICHLOROETHENE	1/33	NA	2.70
PHENOL	1/18	NA	5.00
TRANS-1,2-DICHLOROETHENE	21/30	8.94	80.0
TETRACHLOROETHENE	29/29	26.8	180
TOLUENE	2/2	3.46	4.00
TOTAL-XYLENE	1/33	NA	5.00
1,1,1-TRICHLOROETHANE	14/30	6.12	1700
TRICHLOROETHENE	30/32	17.9	140
INORGANICS (ug/liter)			
ALUMINUM	3/12	183	5800
ARSENIC	1/12	NA	20
BARIUM	3/12	93.4	210
BERYLLIUM	1/14	NA	2.50
CADMIUM	1/14	NA	5.90
CALCIUM	5/14	7010	75000
CHROMIUM	3/14	4.80	20.0
COBALT	2/14	14.3	25.0
COPPER	2/13	15.0	49.0
IRON	2/12	106	7400
LEAD	1/12	NA	58.0
MAGNESIUM	5/14	4390	16300
MANGANESE	5/14	22.8	1100
NICKEL	1/12	NA	36.0
POTASSIUM	5/14	2913	8770
RADIONUCLIDES (a)			
Radium 226 and 228	5/5	2.2	14
gross Alpha	5/5	26	350
gross Beta	5/5	30	180
Uranium	5/5	3.6	6
SILVER	2/14	4.33	5.00
SODIUM	5/14	5927	30500
TIN	1/14	NA	20.0
VANADIUM	5/14	19.8	27.0
ZINC	3/12	16.5	104

NA = Not applicable; mean not calculated with only one positive detection.

(a) Units for the radionuclides are pCi/liter except for uranium data which have units of ug/liter.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE A GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR FO THE FREQUENCY OF DETECTION.

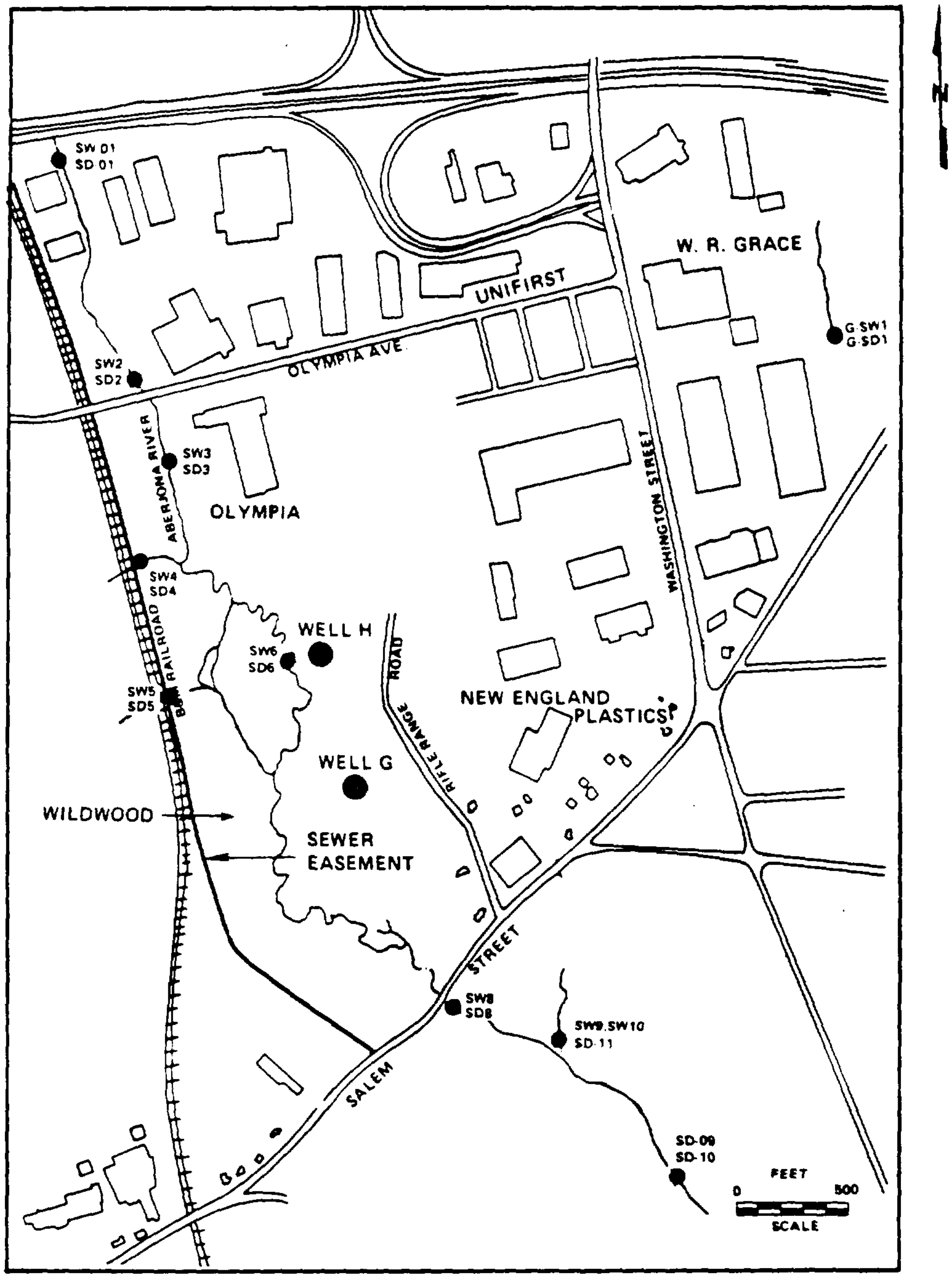
constituents not rejected for the above reasons were aluminum, barium, and silver. Of these compounds, aluminum was not selected as a chemical of potential concern due to insufficient toxicity information; in addition, aluminum was detected once at a level approximately equal to the 10-day suggested no adverse reaction level of 5,000 ug/liter (NAS 1982), although this comparison is not appropriate for chronic exposures. The maximum aluminum concentration suggests that aluminum may be present in the particulate phase or complexed to naturally occurring organic acids rather than as a dissolved ion (Hem 1985). Silver was not selected as a chemical of potential concern after a comparison to other groundwater samples taken from within the study area which revealed that silver was present at similar, low (<10 ug/liter) levels throughout the site. Thus, barium was selected as the inorganic chemical of potential concern for groundwater. It should be noted that the maximum sodium concentrations exceeded the Massachusetts advising level of 20,000 ug/liter for persons on salt restricted diets.

Five wells (S72S, S81S, S84S, S77S, and S22) from the central area were analyzed for radionuclides. With the exception of levels in Well S22, all radionuclide concentrations were below MCLs. It should be noted that Well S22 is a bedrock well and these levels may reflect naturally occurring conditions. The radionuclides were selected as chemicals of potential concern.

7.1.3 SURFACE WATER AND SEDIMENTS

The surface water bodies at the Wells G & H site are not known to be used by humans for swimming and fishing. In addition, there are no known users of river water from the site for drinking water purposes downstream of the site. The Aberjona River does, however, eventually flow into the Mystic Lakes which are used for recreational purposes. Although it is highly unlikely, exposure to humans to the surface water and sediments will be evaluated. Exposure to environmental receptors and selection of chemicals of potential concern for these receptors will be evaluated in Section 8.

Figures 7-3 and 7-4 shows the sampling locations for the surface water and sediments taken in the Aberjona river and the adjacent wetlands. One sample



● SW-01 SURFACE WATER SAMPLING LOCATION

● SD-01 SEDIMENT SAMPLING LOCATION

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WELLS G & H

Figure 7-3

PHASE I SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS AT THE WELLS G&H SITE

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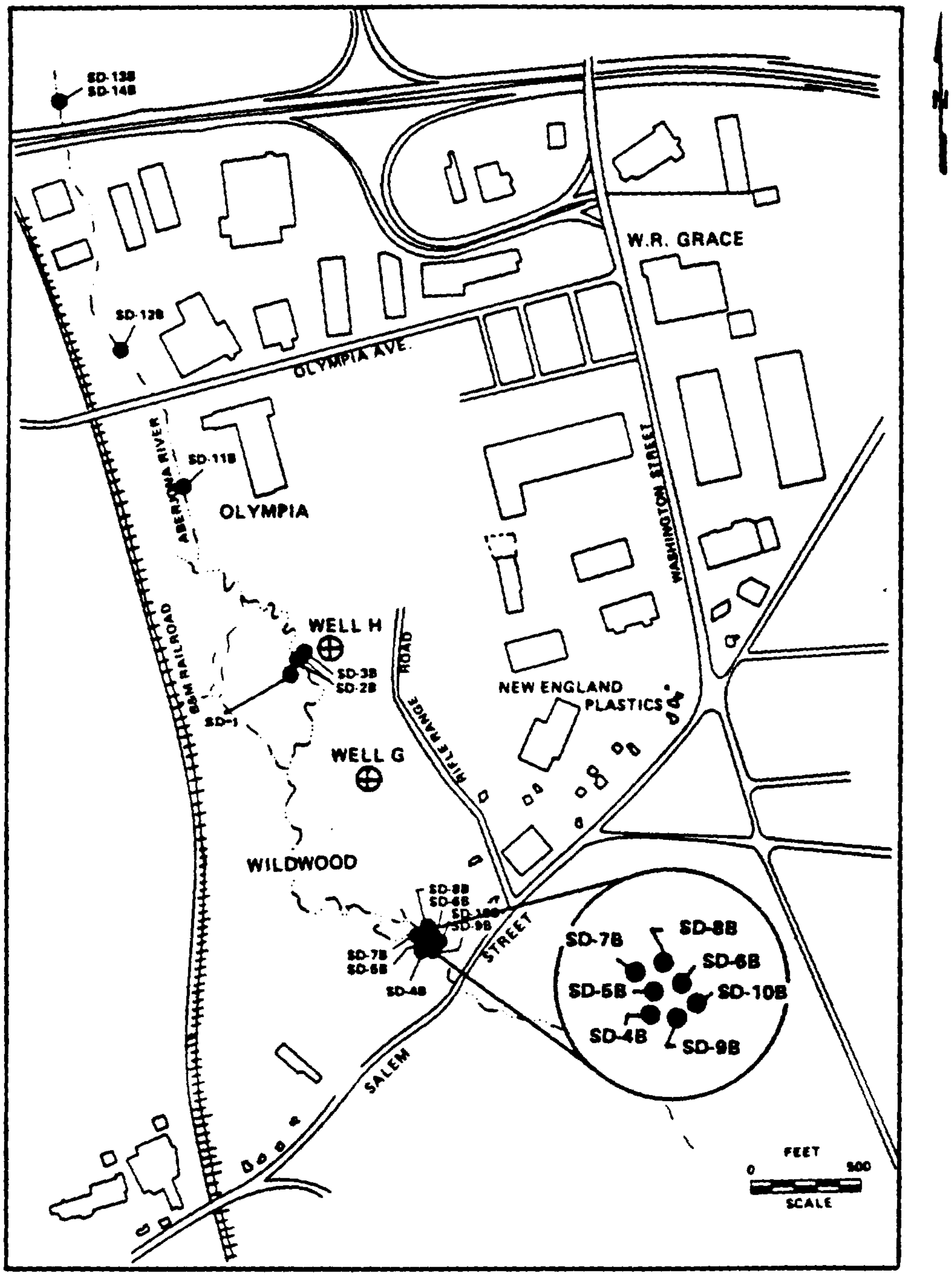

● SD-13B – SEDIMENT SAMPLING LOCATION

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Figure 7-4 APPROXIMATE LOCATIONS OF PHASE II SEDIMENT SAMPLES COLLECTED DURING JUNE 1988
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taken in 1987, SW-01, and SW-06, taken in 1985, were located upstream of the study area and were used as background samples. Sampling locations SW-08, SW-09, and SW-10 were taken downstream of the site. The other samples were grouped together to evaluate potential on-site contamination.

The surface water data (upstream, downstream, and at the site) are presented in Table 7-3. Six volatile organic chemicals were detected in the surface water at the site. Of these, 1,1-dichloroethane and 1,1,1-trichloroethane, were detected at or below levels detected in the upstream samples. Hence, they were not selected as chemicals of potential concern. Toluene was not selected since it was detected at very low levels (1 ug/liter for the maximum). <u>trans</u>-1,2-Dichloroethene, tetrachloroethene, and trichloroethene were selected as chemicals of potential concern. Four phthalate esters were detected in the surface water. Bis(2-ethylhexyl)phthalate was selected as the chemical of potential concern to represent this class of compounds. Chloroform was not selected as a chemical of potential concern since it was only detected in one downstream sample.

The inorganic constituent concentrations were also compared to upstream water concentrations. Arsenic, barium, calcium, copper, magnesium, manganese, potassium, sodium, and zinc were found to be at levels approximately equal to or below upstream concentrations and hence were excluded from further consideration. Beryllium, cadmium, and silver were not selected as chemicals of potential concern since the were only detected once in the onsite stream samples and not in the upstream or downstream samples. Additionally, their concentrations were similar to groundwater background concentrations so that it is likely that their presence is due to natural sources. Aluminum was not selected as a chemical of potential concern due to limited toxicity information and since it was detected below the NAS (1982) 10-day no adverse reaction level of 5,000 ug/liter. Iron was not selected as a chemical of potential concern since it is an essential nutrient. The inorganic chemical of potential concern for surface water is lead because both the geometric mean and maximum concentrations exceed the upstream concentration.

TABLE 7-3
COMPOUNDS DETECTED IN SURFACE WATER AT THE CENTRAL AREA OF THE WELLS G & H SITE

COMPOUND	SITE			UPSTREAM			DOWNSTREAM		
ORGANICS (ug/L)	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
VOLATILES									
CHLOROFORM	ND			ND			1/3	NA	2.00
1,1-DICHLOROETHANE	2/24	NR	2.00	1/4	NA	2.00	ND		
TRANS-1,2-DICHLOROETHENE	2/24	4.18	22.0	ND			ND		
1,1,1-TRICHLORETHANE	13/22	3.48	8.00	3/4	4.30	10.0	ND		
TRICHLOROETHENE	5/24	2.71	26.0	1/3	NA	1.00	1/3	NA	0.50
TETRACHLOROETHENE	2/24	2.59	4.00	ND			ND		
TOLUENE	2/24	NR	1.00	ND			ND		
SEMI-VOLATILES									
BIS(2-ETHYLHEXYL)PHTHALATE	1/1	NA	100	1/1	NA	38.0	ND		
DI-N-OCTYL PHTHALATE	1/5	NA	5.00	ND			ND		
DI-N-BUTYL PHTHALATE	ND			ND			1/2	NA	1.00
BUTYLBENZYL PHTHALATE	2/5	5.90	29.0	1/1	NA	11.0	ND		
INORGANICS (ug/L)									
ALUMINUM	3/6	75.9	548	1/2	NA	25.0	2/3	247	396
ANTIMONY	ND			ND			1/3	NA	57.0
ARSENIC	4/6	5.45	8.80	1/2	NA	8.90	1/3	NA	6.10
BARIUM	5/6	26.0	46.0	2/2	25.5	27.0	3/3	18.1	27.0
BERYLLIUM	ND			1/1	NA	0.70	ND		
CADMIUM	ND			1/2	NA	6.00	ND		
CALCIUM	6/6	31600	43000	2/2	32900	39000	3/3	13300	28000
CHROMIUM	ND			1/2	NA	4.30	ND		
COPPER	2/5	NR	12.0	1/1	NA	10.0	3/3	12.7	17.0
IRON	6/6	1310	5200	2/2	712	1490	3/3	990	1050
LEAD	5/6	3.56	11.0	1/2	NA	2.20	3/3	7.83	20.0
MAGNESIUM	6/6	5090	8100	2/2	6140	7400	3/3	3980	4970
MANGANESE	6/6	377	460	2/2	408	480	3/3	129	230
POTASSIUM	6/6	4010	5700	2/2	4010	4700	3/3	2100	3460
SILVER	ND			1/2	NA	5.90	ND		
SODIUM	6/6	35700	70000	2/2	44000	59000	3/3	23700	33500
ZINC	6/6	141	190	2/2	183	196	3/3	99.2	192

NA = Not applicable; mean not calculated with only one positive detection.
ND = Not detected.
NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

Several of the volatile organic compounds detected in the upstream sediments were also detected at and downstream of the site as seen in Table 7-4. Acetone, 2-butanone, and methylene chloride were detected at higher concentrations at the site than upstream. Acetone and methylene chloride were selected as chemicals of potential concern. 2-Butanone was not selected since it belongs to the same class of compounds as acetone. The other volatile organics were detected at concentrations less than 5 ug/kg and are likely to be present in the sediment pore water rather than on the sediments themselves since they do not have a tendency to adsorbed into soils or sediments. Based on the low levels detected and their physico-chemical properties, benzene, 1,1-dichloroethane, trans-1,2-dichloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, and vinyl chloride were not selected as chemicals of potential concern.

The semivolatiles (base/neutral extractables) and pesticides have a greater tendency to adsorb to sediment particles than do the volatile organics. This tendency is seen in the relatively higher concentrations of these compounds than the volatile organics. A comparison to the upstream samples indicates that higher levels are detected on-site. The downstream samples have higher PAH concentrations which may be the result of a second source or transport of sediment from the site downstream. Bis(2-ethylhexyl)phthalate was selected as a chemical of concern representing the phthalate compounds. Both the potentially carcinogenic and noncarcinogenic PAH compounds were also selected as chemicals of potential concern. Aldrin was the only pesticide detected in the on-site sediments. Hence, it was selected as a chemical of potential concern.

The inorganic sediment concentrations were compared with regional soil background concentrations (Table A-1, Appendix A) as well as with upstream concentrations. Arsenic, cadmium, chromium, copper, mercury, selenium, vanadium, and zinc were detected at levels which exceeded the criteria used to select inorganic chemicals of potential concern (as discussed in Appendix A). Of these compounds, selenium was not selected as a chemical of concern since it was detected only once, and vanadium was not selected due to its low toxicity.

TABLE 7-4
COMPOUNDS DETECTED IN SEDIMENT AT THE CENTRAL AREA OF THE WELLS G & H SITE

CHEMICAL	SITE			UPSTREAM			DOWNSTREAM		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/L)									
VOLATILES									
ACETONE	5/5	164	390	1/1	NA	39.9	3/4	34.5	395
2-BUTANONE	5/5	22.9	72.9	1/1	NA	12.2	1/4	NA	64.7
BENZENE	1/5	NA	4.50	ND			ND		
TOLUENE	4/5	2.22	3.10	ND			ND		
1,1-DICHLOROETHANE	1/5	NA	3.80	ND			ND		
1,1,1-TRICHLORETHANE	1/5	NA	2.80	ND			ND		
TRICHLOROETHENE	2/5	2.03	2.50	ND			ND		
1,2-DICHLOROETHENE	2/5	2.83	4.50	ND			1/4	NA	8.50
VINYL CHLORIDE	1/5	NA	5.00	ND			ND		
METHYLENE CHLORIDE	5/5	105	153	1/1	NA	27.6	4/4	8.15	315
BASE/NEUTRAL EXTRACTABLES									
ACENAPHTHENE	2/5	160	255	ND			2/4	78.0	194
ACENAPHTHYLENE	ND			ND			2/4	72.6	511
ANTHRACENE	3/5	195	606	1/1	NA	49.0	1/4	NA	949
BENZO(A)ANTHRACENE	3/5	439	2070	1/1	NA	314	4/4	36.3	4180
BENZO(A)PYRENE	3/5	426	1650	1/1	NA	283	2/4	149	3670
BENZO(B)FLUORANTHENE	3/5	511	1950	1/1	NA	314	1/4	NA	4210
BENZO(G,H,I)PERYLENE	3/5	271	568	1/1	NA	202	2/4	158	655
BENZO(K)FLUORANTHENE	3/5	410	1340	1/1	NA	298	3/4	87.2	4880
BIS(2-ETHYLHEXYL)PHTHALATE	4/5	532	1340	1/1	NA	246	1/4	NA	1630
BUTYL BENZYL PHTHALATE	ND			ND			1/4	NA	20.0
CHRYSENE	3/5	515	2100	1/1	NA	407	3/4	59.1	4610
DIBENZOFURAN	1/5	NA	115	ND			2/4	67.2	187
DIBENZO(A,H)ANTHRACENE	3/5	174	363	1/1	NA	89.6	1/4	NA	426
DI-N-BUTYL PHTHALATE	ND			ND			2/4	NR	8.00
DI-N-OCTYL PHTHALATE	ND			ND			1/4	NA	6.00
FLUORANTHENE	4/5	767	3990	1/1	NA	519	2/4	199	8150
FLUORENE	1/5	NA	247	ND			1/4	NA	514
INDENO(1,2,3-C,D)PYRENE	3/5	288	649	1/1	NA	163	2/4	159	913
2-METHYL NAPHTHALENE	ND			ND			1/4	NA	1.00
4-METHYLPHENOL	1/5	NA	168	ND			ND		
NAPHTHALENE	1/5	NA	89.1	ND			2/4	75.1	292
N-NITROSODIPHENYLAMINE	ND			ND			1/4	NA	747
PHENANTHRENE	3/5	487	2400	1/1	NA	160	3/4	74.4	3380
PYRENE	4/5	687	3740	1/1	NA	465	1/4	NA	7230
CARCINOGENIC PAHs, TOTAL	3/5	5440	10700	1/1	NA	1920	4/4	145	23800
NONCARCINOGENIC PAHs, TOTAL	4/5	2760	11300	1/1	NA	1350	3/4	247	20900

TABLE 7-4 (continued)
COMPOUNDS DETECTED IN SEDIMENT AT THE CENTRAL AREA OF THE WELLS G & H SITE

CHEMICAL	SITE			UPSTREAM			DOWNSTREAM		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
PESTICIDES/PCB'S									
ALDRIN	4/5	16.5	84.4	1/1	NA	12.1	ND		
4,4'-DDD	ND			ND			1/4	NA	26.9
INORGANICS (mg/Kg)									
ALUMINUM	5/5	8160	48800	1/1	NA	3060	4/4	13700	18400
ARSENIC	5/5	100	3630	1/1	NA	24.0	4/4	121	325
BARIUM	5/5	37.8	63.0	1/1	NA	11.0	4/4	53.3	69.0
BERYLLIUM									
CADMIUM	4/5	2.52	13.0	ND			1/4	NA	8.30
CALCIUM	5/5	2320	7980	1/1	NA	647	4/4	4700	6840
CHROMIUM	5/5	86.6	1250	1/1	NA	12.0	4/4	701	1560
COBALT	ND			ND			3/4	8.84	17.0
COPPER	5/5	125	3010	1/1	NA	25.0	4/4	433	641
IRON	5/5	23800	89400	1/1	NA	10200	4/4	27600	41100
LEAD	ND			1/1	NA	75.0	3/3	251	349
MAGNESIUM	5/5	1810	3310	1/1	NA	1230	4/4	3610	4270
MANGANESE	5/5	260	589	1/1	NA	73.0	4/4	289	397
MERCURY	4/5	0.45	27.0	ND			3/4	1.20	17.0
NICKEL	3/5	9.61	38.0	ND			4/4	18.5	29.0
POTASSIUM	3/5	462	1030	ND			4/4	755	918
SELENIUM	1/5	NA	22.0	ND			ND		
SODIUM	5/5	277	897	1/1	NA	145	4/4	416	618
VANADIUM	3/5	29.6	2500	1/1	NA	8.80	3/4	25.0	70.0
ZINC	5/5	584	5170	1/1	NA	76.0	4/4	976	1520

NA = Not applicable; mean not calculated with only one positive detection.
ND = Not detected.
NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE A GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

7.1.4 SUMMARY

Table 7-5 summarizes the chemicals of potential concern for the central area of the Wells G & H site. The soil chemicals of potential concern are cadmium, chlordane, lead and pyrene. The chemicals of potential concern for the groundwater are barium, trans-1,2-dichloroethene, the radionuclides (gross alpha particles, gross beta particles, radium, and uranium), tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene. The chemicals of potential concern for the surface water are bis(2-ethylhexyl)phthalate, trans-1,2-dichloroethene, lead, tetrachloroethene, and trichloroethene. Acetone, aldrin, arsenic, bis(2-ethylhexyl)phthalate, cadmium, chromium, copper, methylene chloride, mercury, the carcinogenic and noncarcinogenic PAHs and zinc are the chemicals of potential concern for the sediments.

7.2 EXPOSURE ASSESSMENT

7.2.1 CENTRAL AREA UNDER CURRENT-USE CONDITIONS

Under current-use conditions, the complete exposure pathways are related to all environmental media (i.e., groundwater, soil, surface water, and sediment exposures). These pathways will be discussed below. Groundwater is not currently used as a drinking water source. It is, however, used by the Riley Tannery for their production processes.

Groundwater, drawn from Well S-47 in Figure 7-1, is used in the production process at the Riley Tannery. The Riley Tannery is not located within the Wells G & H site, although their production well is located at the site. Water is stored in vessels or drums at the tannery. There are 21 vessels with a 12 ft. diameter, 14 drums with a 20 ft. diameter, and 7 drums with a 8 ft. diameter. A surface water volatilization model, outlined in Appendix C, was used to estimate indoor air concentrations. Table 7-6 summarizes the results of the model.

The rifle range north of Well H is used for recreational purposes. A soil sample was collected from what appeared to be a surface soil stain. Exposure

TABLE 7-5

CHEMICALS OF POTENTIAL CONCERN FOR THE CENTRAL AREA
OF THE WELLS G & H SITE

SOIL	GROUNDWATER	SURFACE WATER	SEDIMENTS
Cadmium	Aldrin	Bis(2-ethylhexyl)phthalate	Acetone
Chlordane	Barium	trans-1,2-Dichloroethene	Arsenic
Lead	trans-1,2-Dichloroethene	Lead	Bis(2-ethylhexyl)-phthalate
Pyrene	Radionuclides[a]	Tetrachloroethene	Cadmium
	Tetrachlorethene	Trichloroethene	Chromium
	1,1,1-Trichloroethane		Copper
	Trichloroethene		Iron
			Lead
			Mercury
			Methylene chloride
			Nickel
			cPAHs[b]
			nPAHs[c]
			Zinc

[a]Radionuclides are gross alpha particles, gross beta particles, radium, and uranium.

[b]Carcinogenic polynuclear aromatic hydrocarbons.

[c]Noncarcinogenic polynuclear aromatic hydrocarbons.

TABLE 7-6

CONCENTRATION OF CHEMICALS OF POTENTIAL CONCERN IN PROCESS WATER AND INDOOR AIR AT THE RILEY TANNERY USING CENTRAL AREA GROUNDWATER

	Water Concentration (ug/liter)		Air Concentration $(mg/m)^3$	
Compound	Geometric Mean	Maximum	Average	Maximum
trans-1,2-Dichloroethene	8.05	259	3.88×10^{-3}	1.35×10^{-2}
Tetrachloroethene	5.48	12.0	2.07×10^{-3}	4.53×10^{-3}
1,1,1-Trichloroethane	7.97	25.4	3.38×10^{-3}	1.10×10^{-2}
Trichloroethene	23.4	220	9.80×10^{-3}	9.19×10^{-2}

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

of individuals to this spot is evaluated to determine whether or not the levels of contaminants present at this location poses a threat to human health and this spot should be remediated. Individuals using this area could be exposed to contaminated soil via dermal absorption from or incidental ingestion of soil. It is assumed that for the average case scenario, an individual will be at this location five days a week for five months a year, (i.e., 100 visits a year) for ten years. For the plausible maximum exposure scenario, an individual will be in this location seven days a week for six months a year or 168 visits a year for thirty years. The soil concentrations an individual could be exposed to are summarized in Table 7-7.

The Aberjona River may be used for recreational purposes such as wading or trapping. Occasional contact can occur. A trapper is known to set water traps and children may wade in the water. Thus, exposure to humans using the river will be evaluated in this assessment. The exposure point concentrations are summarized in Table 7-8.

The Aberjona River and wetlands are used by wildlife in the area. The wetlands assessment (Alliance 1987) describes the habitat and wildlife found within the Wells G & H study area. In brief, the wetlands at the Wells G & H site provide a habitat for a variety of mammals, birds, amphibians, and reptiles. It is probable that all are exposed to the contaminated surface water and sediments. Section 8.0 will provide a more detailed description of exposure to environmental receptors.

7.2.2 PROPERTY UNDER FUTURE-USE CONDITIONS

In the absence of institutional controls limiting access of future uses of the central area of the Wells G & H study area, there are several exposure pathways which must be considered. If the central area were developed, construction activities or excavations for utilities would create the potential for workers to be exposed to contaminated soils. This exposure scenario will not be evaluated because only one soil sample was collected during the 1987 sampling effort (Ebasco 1988a). Since it is not known whether or not this sample is representative of this area, only exposure under current

TABLE 7-7

SOIL CONCENTRATIONS OF THE CHEMICALS OF POTENTIAL CONCERN
FOR THE CENTRAL AREA

COMPOUND	SOIL CONCENTRATION (mg/kg)
Cadmium	2.50
Chlordane	0.53
Lead	161
Pyrene	2.30

TABLE 7-8

SURFACE WATER AND SEDIMENT CONCENTRATIONS OF CHEMICALS OF CONCERN FOR THE CENTRAL AREA

COMPOUND	CONCENTRATION GEOMETRIC MEAN	CONCENTRATION MAXIMUM
Surface Water (ug/liter)		
Bis(2-ethylhexyl)phthalate	NA	100
trans-1,2-Dichloroethene	4.18	22.0
Lead	3.56	11.0
Tetrachloroethene	2.59	4.00
Trichloroethene	2.71	26.0
Sediments (mg/kg)		
Acetone	0.16	0.39
Aldrin	0.016	0.084
Arsenic	180	4650
Bis(2-ethylhexyl)phthalate	0.53	1.34
Cadmium	2.17	16.2
Chromium	104	1250
Copper	154	3010
Iron	19000	108000
Lead	26.0	120
Mercury	0.66	29.9
Methylene Chloride	0.10	0.15
Nickel	13.1	52.6
cPAHs[a]	5.44	10.7
nPAHs[b]	2.76	11.3
Zinc	739	6000

[a]Carcinogenic polynuclear aromatic hydrocarbons
[b]Noncarcinogenic polynuclear aromatic hydrocarbons
NA = Not applicable; mean not calculated with only one positive detection.

conditions (as discussed earlier in this chapter) will be evaluated. Future development of the area may result in increased contact with sediments and surface water as compared with the current-use scenario. However, this scenario will not be evaluated further since the frequency of contact would increase the exposure and subsequent risk only slightly (perhaps by a factor of 2 at most).

It is possible that in the future, this area will be developed for residential purposes. Should this occur, the potential exists for residents to install a drinking water well in the groundwater. Thus, one exposure scenario would involve the ingestion of groundwater. Table 7-9 summarizes the groundwater data used in the ingestion of groundwater exposure scenario. Should this water be used in a residential setting, exposures could occur via inhalation and dermal contact from bathing or showering, washing clothes, cooking, washing dishes, and any other household activities which involve the use of water. In this endangerment assessment, exposure via ingestion and dermal contact and inhalation while showering will be quantified. The assumptions used in estimating exposures are summarized in Section C.2 of Appendix C.

The groundwater concentrations of the chemicals of potential concern summarized in Table 7-9 were used to estimate the concentrations that might be expected to occur while showering. Exposure to arsenic and barium via this pathway is not evaluated because they are nonvolatile chemicals of potential concern. Using a theoretical exposure model, outlined in Section C.2 of Appendix C (Foster and Chrostowski 1986, 1987), the transfer of volatile organic compounds from shower droplets into the air and their subsequent inhalation were estimated. Based on this exposure model, the potential inhalation exposures to the groundwater contaminants which could volatilize were quantified. The model does not estimate dermal absorption of contaminants while showering. However, given the exposure scenario and the physical and chemical properties of the organic compounds considered in this assessment, dermal absorption is likely to result in minimal exposure as compared to exposure via inhalation. The model estimates the intake level (in mg/kg/day), rather than the ambient air concentrations that might be expected while showering.

TABLE 7-9

GROUNDWATER CHEMICALS OF POTENTIAL CONCERN
FOR THE CENTRAL AREA OF THE WELLS G & H SITE

(ug/liter)

COMPOUND	CONCENTRATION	
	GEOMETRIC MEAN	MAXIMUM
Barium	93.4	210
trans-1,2-Dichloroethene	8.3	80
Radionuclides (pCi/liter)		
Gross alpha particles	26	350
Gross beta particles	30	180
Radium 226 & 228	2.2	14
Uranium	2.4	4
Tetrachloroethene	24.0	180
1,1,1-Trichloroethane	4.8	1700
Trichloroethene	16.7	140

These values are presented in Table 7-10 for the geometric mean and maximum concentrations of the contaminants in groundwater.

Exposure to environmental receptors would remain the same and hence, will not be reevaluated under the future-use exposure scenarios. This exposure will be evaluated in Section 8.0 of this report.

7.3 RISK ASSESSMENT

According to guidelines for preparing risk assessments as part of the RI/FS process (EPA 1986a), the potential adverse effects on human health should first be assessed where possible by comparing chemical concentrations found in environmental media at or near the site with applicable or relevant and appropriate requirements (ARARs) or other guidance that has been developed for the protection of human health or the environment. If ARARs are not available for all chemicals and exposures considered, quantitative risk estimates must be developed in addition to the comparison to ARARs. This section will present a comparison of exposure point concentrations to the applicable or relevant and appropriate requirements (ARARs) as well as a quantitative risk assessment.

7.3.1 COMPARISON TO APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OR OTHER CRITERIA

In this section, the concentrations of chemicals of potential concern in groundwater at the central area of the Wells G & H site are compared to ARARs and other criteria. Table 7-11 presents this comparison, and as can be seen from the table, the geometric mean and maximum concentrations of trichloroethene exceeds its MCL. Barium was detected at concentrations below the MCL. The geometric mean and maximum concentrations of gross alpha particles and radium exceeded the MCLs. The maximum gross beta particle concentration exceeds the MCL while the geometric mean concentration is below the MCL. It should be noted that four of the five wells sampled for radionuclides had concentrations below the MCLs.

TABLE 7-10

INTAKE OF CHEMICALS OF POTENTIAL CONCERN RELEASED TO THE AIR WHILE SHOWERING WITH GROUNDWATER FROM THE CENTRAL AREA

	INTAKE (mg/kg/day)	
COMPOUND	GEOMETRIC MEAN	MAXIMUM
trans-1,2-Dichloroethene	2.32×10^{-4}	2.24×10^{-3}
Tetrachloroethene	5.58×10^{-4}	4.19×10^{-3}
1,1,1-Trichloroethane	1.22×10^{-4}	4.31×10^{-2}
Trichloroethene	4.20×10^{-4}	3.52×10^{-3}

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 7-11

COMPARISON OF CHEMICALS OF POTENTIAL CONCERN IN THE GROUNDWATER AT THE CENTRAL AREA OF THE WELLS G & H SITE WITH ARARS AND OTHER GUIDANCE LEVELS

(mg/liter)

Compound	Concentration: Geometric Mean	Concentration: Maximum	ARAR: MCL	Massachusetts Drinking Water Standard
Barium	0.0934	0.2100	1.0	1.0
trans-1,2-Dichloroethene	0.0083	0.0800	--	0.07 (a,b)
Radionuclides (pCi/l)				
Gross alpha particles (c)	26	350	15	15
Gross beta particles	30	180	50	4 mrem/year
Radium-226 or -228	22	14	5	--
Uranium (mg/l)	0.0036	0.006	--	--
Tetrachloroethene	0.0240	0.1800	--	0.005
1,1,1-Trichloroethane	0.0048	1.7000	0.20	0.20
Trichloroethene	0.0167	0.0140	0.005	0.005

-- = Not available.
(a) Proposed.
(b) Shall not exceed health advisories which have been adopted by the Massachusetts Division of Water Pollution Control and/or the EPA. For groundwater, this would equate to the Clean Water Act criteria for human health (drinking water only) or the Safe Drinking Water Act Maximum Concentration Limit Goals, whichever is more stringent.
(c) The MCL for gross alpha particles includes radium-226 but excludes radon and uranium.

The maximum concentration of 1,1,1-trichloroethane exceeds its MCL. The maximum concentration of trans-1,2-dichloroethene exceeds its Massachusetts drinking water standard. The geometric mean and maximum concentrations of tetrachloroethene exceed its Massachusetts drinking water standard.

7.3.2 QUANTITATIVE RISK CHARACTERIZATION

To quantitatively assess the risks to human health associated with the future-use exposure scenarios considered in this assessment, the concentrations of chemicals in relevant environmental media (exposure point concentrations) presented in Section 7.2 are converted to chronic daily intakes (CDIs). CDIs are the amount of a substance taken into the body per unit body weight per unit time, expressed in units of mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA 1986b) and over the exposure period for noncarcinogens (EPA 1986c).

Section 1.4.4 summarized the methodology that will be used in this section.

In this section of the risk assessment, the intakes of chemicals of potential concern by potentially exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions such as frequency and duration of exposure. For each exposure scenario evaluated, two exposure cases--an average case and plausible maximum case--are considered. For the average exposure case, geometric mean concentrations are used together with what are considered to be the most likely (although conservative) exposure conditions. For the plausible maximum case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the plausible maximum case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

Chronic daily intakes, excess lifetime cancer risks, and CDI:RfD ratios for the site-related chemicals considered in this assessment, as well as the assumptions and procedures used to calculate these values, are shown below for each scenario evaluated.

As was discussed in Section 7.2.1, there are no human exposure pathways that are currently complete. In the absence of future remedial actions and institutional actions limiting access to the property for redevelopment, individuals could be exposed to groundwater. Exposure to groundwater could involve ingestion or inhalation of volatilized contaminants while using the water for nonconsumptive uses.

7.3.2.1 Property Under Current-Use Conditions

Inhalation of Volatiles Released During Process Related Activities. The Riley Tannery has a production well in the central area of the Wells G & H site which draws water that is used in the tanning process ar the facility. The groundwater is drawn and placed in tanks which are used at the facility. Indoor air concentrations were derived in Section 7.2.1 assuming that the levels of the chemicals of concern detected in Well S46 in 1985 and Well S47 in 1987 apply to water presently drawn.

The assumption used in the evaluation are summarized in Table 7-12. It is assumed that an individual works in the facility eight hours a day, five days each week, for 50 weeks a year. The individual works at this facility for 10 years and 20 years under average and plausible maximum exposure scenarios, respectively. Using the assumptions, chronic daily intake (CDI) estimates for inhalation of volatiles by workers at the facility can be calculated. The formulae used are presented in Section C.4 of Appendix C of this endangerment assessment. Table 7-13 presents the average and plausible maximum CDIs and the potential carcinogenic and noncarcinogenic risks associated with these exposures.

The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are 2×10^{-6} (i.e., two in one million) and 3×10^{-5} (i.e., three in one hundred thousand) for the average and plausible maximum exposure cases, respectively. Exposure to the chemicals

TABLE 7-12

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR INDOOR AIR EXPOSURE BY WORKERS AT THE RILEY TANNERY USING WATER FROM THE CENTRAL AREA

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	8 hr/day for 50 weeks/yr	8 hr/day for 50 weeks/yr
Duration of Exposure	10 yr	20 yr
Average Weight	70 kg	70 kg
Inhalation Rate	2.6 m^3/hr	2.6 m^3/hr
Average Lifetime	70 yr	70 yr

TABLE 7-13

EXPOSURE AND RISKS ASSOCIATED WITH THE INHALATION OF VOLATILE ORGANIC COMPOUNDS RELEASED DURING INDUSTRIAL PROCESSES AT THE RILEY TANNERY USING CENTRAL AREA WATER

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE 70-kg ADULT PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE 70-kg ADULT PRORATED OVER A 70-YEAR LIFETIME (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Tetrachloroethene	2.07E-03	4.53E-03	6.02E-05	2.63E-04	3.30E-03	2.0E-07	8.7E-07
Trichloroethene	9.80E-03	9.19E-02	2.85E-04	5.34E-03	4.60E-03	1.3E-06	2.5E-05
TOTAL						2E-06	3E-05

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	CONCENTRATION IN AIR (mg/m3) GEOMETRIC MEAN	CONCENTRATION IN AIR (mg/m3) MAXIMUM	CHRONIC DAILY INTAKE (CDI), 70-kg ADULT (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI), 70-kg ADULT (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
trans-1,2-Dichloroethene	3.88E-03	1.35E-02	7.90E-04	2.75E-03	1.00E-02	7.90E-02	2.75E-01
Tetrachloroethene	2.07E-03	4.53E-03	4.21E-04	9.22E-04	2.00E-02	2.11E-02	4.61E-02
1,1,1-Trichloroethane	3.38E-03	1.10E-02	6.88E-04	2.24E-03	3.00E-01	2.29E-03	7.46E-03
HAZARD INDEX						<1 (0.1)	<1 (0.3)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the size of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

exhibiting noncarcinogenic effects appears to represent a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, since the hazard indices are less than one.

Direct contact with contaminated soil. Under current-use conditions, individuals using the rifle range to the north of Well H could come in contact with the stained surface soil. Direct contact with the contaminated soil could lead to dermal contact and absorption of contaminants, as well as inadvertent ingestion of the compounds. Table 7-14 presents the assumptions used in assessing exposure via these pathways. These assumptions were based on the exposure pathway analysis presented in Section 7.2 and the best currently available information. EPA standard assumptions for average lifetime (70 years) and adult body weight (70 kg) were used (EPA 1985c).

Average and plausible maximum incidental ingestion rates for individuals are 25 and 100 mg/day. The derivation of these rates is discussed in Appendix C, and was based primarily on the work of LaGoy (1987).

Values of 400 and 930 mg/day are used as the average and plausible maximum estimates of soil contact rates for dermal exposure. These values are contact rates in mg soil/cm^2 skin (0.5 - 1.5 mg/cm^2) from Schaum (1984), surface area of parts of the body that are likely to be in contact with soil (e.g., approximately 840 cm^2 for the palms for the hands and 1,140 cm^2 for the forearms) from Anderson et al. (1985), and of certain subjective factors. Although these are reasonable values they have not been validated and are a source of uncertainty in the risk calculation.

The derivation of the absorption factors are summarized in Appendix C, Section C.3. These factors are based upon the likelihood that the chemicals will be adsorbed into the soil (e.g., pesticides, PAHs) and hence, be less bioavailable than these same chemicals in drinking water, for example.

Using these assumptions, chronic daily intake (CDI) estimates for incidental ingestion and dermal absorption of chemical contaminants can be calculated. The formulae used are presented in Appendix C, Section C.3, of this

TABLE 7-14

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT WITH SOIL BY INDIVIDUALS AT THE CENTRAL AREA

Parameters	Average Exposure	Plausible Maximum Exposure
Frequency of Exposure	100 days/year	168 days/year
Duration of Exposure	10 yr	30 yr
Average Body Weight	70 kg	70 kg
Incidental Ingestion Rate	25 mg/day	100 mg/day
Percent PAHs and Pesticides Absorbed from Ingested Soils	15%	45%
Percent Inorganic Compounds Absorbed from Ingested Soils	100%	100%
Soil Contact Rate	400 mg/day	990 mg/day
Percent PAHs and Pesticides Absorbed Dermally from Skin	0.3%	3%
Percent Inorganic Compounds Absorbed Dermally from Skin	Negligible	Negligible
Average Lifetime	70 years	70 years

Endangerment Assessment. The total CDI associated with direct contact with soils is the sum of the CDIs form incidental ingestion and dermal absorption. Table 7-15 presents the average and plausible maximum CDIs, as well as the potential carcinogenic and noncarcinogenic risks associated with these exposures.

The upper bound lifetime excess cancer risks associated with chemicals exhibiting potential carcinogenic effects are $2x10^{-9}$ (i.e., two in one billion) and $1x10^{-7}$ (i.e., one in ten million) for the average and plausible maximum exposure cases, respectively. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

Incidental ingestion of surface water. As discussed previously, individuals trapping or wading in the Aberjona River may be exposed to contaminated surface water. Exposure to both adults and children will be evaluated. Adults are assumed to trap once a week under average conditions and twice a week under plausible maximum conditions for 4 months each year. Average exposure is assumed to occur for 5 years and plausible maximum exposure for 20 years. It is assumed that the individual is assumed to ingest 5 and 25 ml/day under average and plausible maximum exposure conditions. The exposure assumptions are summarized in Table 7-16. The formula used to evaluate this scenario is presented in Appendix C, Section C.5 of this endangerment assessment.

The CDIs and associated risks calculated using these assumptions are presented in Table 7-17. The upperbound excess lifetime cancer risks are $4x10^{-11}$ (i.e., four in ten million) for the average exposure conditions and $1x10^{-8}$ (i.e., one in ten billion) for plausible maximum exposure conditions. Exposure to chemicals exhibiting noncarcinogenic effects appears to represent a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, since the hazard indices are less than one.

TABLE 7-15

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SURFACE SOILS BY INDIVIDUALS USING THE CENTRAL AREA

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SOIL CONCENTRATION (mg/kg)	QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE 70 kg ADULT, PRORATED OVER 70-YEAR LIFETIME (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
		AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Chlordane	5.30E-01	1.11E-09	6.72E-08	3.56E-10	4.44E-08	1.47E-09	1.12E-07	1.30E+00	1.9E-09	1.5E-07
TOTAL									2E-09	1E-07

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	SOIL CONCENTRATION (mg/kg)	QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE (CDI), 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
		AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Cadmium	2.50E+00	2.45E-07	1.64E-06	NQ	NQ	2.45E-07	1.64E-06	5.00E-04	4.9E-04	3.3E-03
Chlordane	5.30E-01	7.78E-09	1.57E-07	2.49E-09	1.04E-07	1.03E-08	2.60E-07	5.00E-05	2.1E-04	5.2E-03
Lead	1.61E+02	1.58E-05	1.06E-04	NQ	NQ	1.58E-05	1.06E-04	6.00E-04	2.6E-02	1.8E-01
Pyrene (b)	2.30E+00	6.81E-07	6.81E-07	4.49E-07	4.49E-07	1.13E-06	1.13E-06	4.10E-01	2.8E-06	2.8E-06
HAZARD INDEX									<1 (0.03)	<1 (0.2)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

(b) The reference dose used for pyrene is that derived for naphthalene, the only noncarcinogenic polynuclear aromatic hydrocarbon for which an RfD has been derived.

NQ = Not quantified; dermal absorption of inorganics is negligible.

TABLE 7-16

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT WITH SEDIMENTS BY INDIVIDUALS AT THE CENTRAL AREA

Parameters	Average Exposure	Plausible Maximum Exposure
<u>General</u>		
Frequency of Exposure	16 days/year	32 days/year
Percent Phthalates, PAHs, PCBs, Pesticides Absorbed Dermally	0.3%	3%
Percent Other Organic Compounds Absorbed Dermally	1%	10%
<u>Adults</u>		
Sediment Contact Rate	420 mg/day	1,260 mg/day
Duration of Exposure	5 years	30 years
Average Body Weight	70 kg	70 kg
<u>Children</u>		
Sediment Contact Rate	300 mg/day	900 mg/day
Duration of Exposure	5 years	5 years
Average Body Weight	27 kg	27 kg

TABLE 7-17

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF SURFACE WATER BY ADULTS AT THE CENTRAL AREA

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	100	NA	8.95E-07	8.40E-03	NA	7.5E-09
Tetrachloroethene	2.59	4.00	5.79E-10	3.58E-08	5.10E-02	3.0E-11	1.8E-09
Trichloroethene	2.71	26.0	6.06E-10	2.33E-07	1.10E-02	6.7E-12	2.6E-09
TOTAL	--	--	--	--	--	4E-11	1E-08

B. NONCARCINOGENIC EFFECTS

COMPOUND	CONCENTRATION (ug/L) GEOMETRIC MEAN	CONCENTRATION (ug/L) MAXIMUM	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	100	NA	3.13E-06	2.00E-02	NA	1.6E-04
trans-1,2-Dichloroethene	4.18	22.0	1.31E-08	6.89E-07	1.00E-02	1.3E-06	6.9E-05
Lead	3.56	11.0	1.11E-08	3.44E-07	6.00E-04	1.9E-05	5.7E-04
Tetrachloroethene	2.59	4.00	8.11E-09	1.25E-07	2.00E-02	4.1E-07	6.3E-06
HAZARD INDEX	--	--	--	--	--	<1 (2E-05)	<1 (8E-04)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NA = Not applicable; mean not calculated with only one positive detection.

Children between 6 and 10 years of age are assumed to play in the Aberjona River once a week (average case) or twice a week (plausible maximum case) for four months each year, for a total of 16 or 32 exposure events each year. The total years of exposure are assumed to be five. The child is assumed to ingest 100 ml/day and 200 ml/day under average and plausible maximum exposure conditions. The exposure assumptions are summarized in Table 7-15 and the formula used to evaluate this scenario are presented in Appendix C, Section C.5.

The CDIs and associated risks calculated using these assumptions are presented in Table 7-18. The upper bound excess lifetime cancer risks are 2×10^{-9} (i.e., two in one hundred billion) and 6×10^{-8} (i.e., six in ten billion) for average and plausible maximum exposure conditions, respectively. Exposure to chemicals exhibiting noncarcinogenic effects appear to represent a low probability of adverse health effects since the hazard indices are less than one for both the average and plausible maximum exposure cases.

Direct contact with contaminated sediments. Individuals trapping or wading in the Aberjona River can also be exposed to contaminated sediments. The approach to calculating chronic daily intakes for these exposure pathways is identical to that used for the direct contact with soil exposure scenario discussed previously, except that only dermal contact and absorption is assessed. Incidental ingestion of sediments is considered unlikely because the sediments are likely to be washed off the hands for the trappers and the hands and feet for children in the water before reaching the mouth. Since dermal absorption of metals through the skin is negligible, exposure to arsenic, cadmium, chromium, copper, mercury, and zinc is not evaluated.

Under this pathway, adults are again assumed to contact sediments 16 times each year for 5 years for average exposure conditions or 32 times each year for 20 years. Sediment contact rates of 420 mg/day and 1,260 mg/day are used for the average and plausible maximum cases, respectively. These values were derived using soil contact rates of 0.5 mg/cm^2 and 1.5 mg/cm^2 (Schaum 1984) and an assumed exposed surface area of 840 cm^2, representing the average surface area for the palms of the hands (Anderson et al. 1985). The dermal

TABLE 7-18

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF SURFACE WATER BY CHILDREN AT THE CENTRAL AREA

A. POTENTIAL CARCINOGENIC EFFECTS

	CONCENTRATION (ug/L)		CHRONIC DAILY INTAKE (mg/kg/d)			LIFETIME UPPER BOUND EXCESS CANCER RISK	
COMPOUND	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	100	NA	4.64E-06	8.40E-03	NA	3.9E-08
Tetrachloroethene	2.59	4.00	3.00E-08	1.86E-07	5.10E-02	1.5E-09	9.5E-09
Trichloroethene	2.71	26.0	3.14E-08	1.21E-06	1.10E-02	3.5E-10	1.3E-08
TOTAL	--	--	--	--	--	2E-09	6E-08

B. NONCARCINOGENIC EFFECTS

	CONCENTRATION (ug/L)		CHRONIC DAILY INTAKE (CDI) (mg/kg/d)			RATIO OF CDI:RfD	
COMPOUND	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	AVERAGE	PLAUSIBLE MAXIMUM
Bis(2-ethylhexyl)phthalate	NA	100	NA	6.49E-05	2.00E-02	NA	3.2E-03
trans-1,2-Dichloroethene	4.18	22.0	6.79E-07	1.43E-05	1.00E-02	6.8E-05	1.4E-03
Lead	3.56	11.0	5.78E-07	7.14E-06	6.00E-04	9.6E-04	1.2E-02
Tetrachloroethene	2.59	4.00	4.20E-07	2.60E-06	2.00E-02	2.1E-05	1.3E-04
HAZARD INDEX	--	--	--	--	--	<1 (0.001)	<1 (0.02)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NA = Not applicable; mean not calculated with only one positive detection.

absorption factors are identical to those in the soil direct-contact scenario. The exposure assumptions are summarized in Table 7-19.

The CDIs and associated risks calculated using these assumptions are presented in Table 7-20. The upper bound excess lifetime cancer risks resulting from sediment exposure are 3×10^{-7} (i.e., three in ten million) under the average case and 4×10^{-4} (i.e., four in ten thousand) under the plausible maximum case. Exposure to chemicals exhibiting noncarcinogenic effects appears to represent a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, since the hazard indices are less than one.

Children between 6 and 10 years of age and weighing 27 kg are assumed to wade in the Aberjona River 16 or 32 times each year for five years (as discussed above). Sediment contact rates of 300 mg/day and 1,000 mg/day are used for the average and plausible maximum cases respectively, derived using the soil contact rates of Schaum (1984) presented above and an assumed exposed surface area of 693 cm^2 representing the average surface area of the feet of male and female children between 6 and 10 years of age (EPA 1985c). The dermal absorption factors are the same as those used in the direct contact with soils exposure scenario. The exposure assumptions are summarized in Table 7-20.

Table 7-21 presents the CDIs and risks calculated using these assumptions. The lifetime upper bound excess cancer risk resulting from exposure of children to the sediments in Aberjona River is 8×10^{-7} (i.e., eight in ten million) under the average case and 2×10^{-4} (i.e., two in ten thousand) under the plausible maximum case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to represent a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure since the hazard indices are less than one.

7.3.2.2 Property Under Future-Use Conditions

Ingestion of groundwater - future-use scenario. Individuals could be exposed to groundwater contaminants by direct ingestion of tap water. The average

TABLE 7-19

ASSUMPTIONS FOR USE IN RISK ASSESSMENT FOR DIRECT CONTACT WITH SEDIMENTS BY INDIVIDUALS AT THE CENTRAL AREA

Parameters	Average Exposure	Plausible Maximum Exposure
General		
Frequency of Exposure	16 days/year	32 days/year
Percent Phthalates, PAHs, PCBs, Pesticides Absorbed Dermally	0.3%	3%
Percent Other Organic Compounds Absorbed Dermally	1%	10%
Adults		
Sediment Contact Rate	420 mg/day	1,260 mg/day
Duration of Exposure	5 years	30 years
Average Body Weight	70 kg	70 kg
Children		
Sediment Contact Rate	300 mg/day	1,000 mg/day
Duration of Exposure	5 years	5 years
Average Body Weight	27 kg	27 kg

TABLE 7-20

EXPOSURES AND RISKS ASSOCIATED WITH DIRECT CONTACT OF SEDIMENTS BY ADULTS USING THE CENTRAL AREA

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE 70 kg ADULT, PRORATED OVER 70-YEAR LIFETIME (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Aldrin	1.65E-02	8.44E-02	2.77E-12	2.04E-09	9.30E-13	1.71E-09	3.70E-12	3.75E-09	1.70E+01	6.3E-11	6.4E-08
Arsenic	1.80E+02	4.65E+03	2.01E-07	2.50E-04	NQ	NQ	2.01E-07	2.50E-04	1.50E+00	3.0E-07	3.7E-04
Bis(2-ethylhexyl)phthalate	5.32E-01	1.34E+00	8.92E-11	3.24E-08	3.00E-11	2.72E-08	1.19E-10	5.96E-08	8.40E-03	1.0E-12	5.0E-10
Methylene chloride	1.05E-01	1.53E-01	1.17E-10	8.21E-09	1.97E-11	1.03E-08	1.37E-10	1.86E-08	7.50E-03	1.0E-12	1.4E-10
cPAHs (b)	5.44E+00	1.07E+01	9.12E-10	2.58E-07	3.07E-10	2.17E-07	1.22E-09	4.76E-07	1.15E+01	1.4E-08	5.5E-06
TOTAL										3E-07	4E-04

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE (CDI), 70 kg ADULT (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Acetone	1.64E-01	3.90E-01	2.57E-09	4.88E-08	9.06E-07	6.15E-08	9.08E-07	1.10E-07	1.00E-01	9.1E-06	1.1E-06
Bis(2-ethylhexyl)phthalate	5.32E-01	1.34E+00	1.25E-09	7.55E-08	4.20E-10	6.34E-08	1.67E-09	1.39E-07	2.00E-02	8.3E-08	6.9E-06
Cadmium	2.17E+00	1.62E+01	3.40E-08	2.03E-06	NQ	NQ	3.40E-08	2.03E-06	5.00E-04	6.8E-05	4.1E-03
Chromium	1.04E+02	1.25E+03	1.63E-06	1.57E-04	NQ	NQ	1.63E-06	1.57E-04	5.00E-03	3.3E-04	3.1E-02
Copper	1.54E+02	3.01E+03	2.41E-06	3.77E-04	NQ	NQ	2.41E-06	3.77E-04	3.70E-02	6.5E-05	1.0E-02
Iron	1.90E+04	1.08E+05	2.97E-04	1.35E-02	NQ	NQ	2.97E-04	1.35E-02	1.00E+00	3.0E-04	1.4E-02
Lead	2.60E+01	1.20E+02	4.07E-07	1.50E-05	NQ	NQ	4.07E-07	1.50E-05	6.00E-04	6.8E-04	2.5E-02
Mercury	6.60E-01	2.99E+01	1.03E-08	3.74E-06	NQ	NQ	1.03E-08	3.74E-06	1.40E-03	7.4E-06	2.7E-03
Methylene chloride	1.05E-01	1.53E-01	1.64E-09	1.92E-08	5.80E-07	2.41E-08	5.82E-07	4.33E-08	6.00E-02	9.7E-06	7.2E-07
Nickel	1.31E+01	5.26E+01	2.05E-07	6.59E-06	NQ	NQ	2.05E-07	6.59E-06	2.00E-02	1.0E-05	3.3E-04
nPAHs (c)	2.76E+00	1.13E+01	6.48E-09	6.37E-07	2.18E-09	5.35E-07	8.66E-09	1.17E-06	4.10E-01	2.1E-08	2.9E-06
Zinc	7.39E+02	6.00E+03	1.16E-05	7.51E-04	NQ	NQ	1.16E-05	7.51E-04	2.10E-01	5.5E-05	3.6E-03
HAZARD INDEX										<1 (0.002)	<1 (0.09)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number).
A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).
(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(b) Carcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.
NQ = Not quantified; dermal absorption of inorganics is negligible.

TABLE 7-21

EXPOSURES AND RISKS ASSOCIATED WITH CONTACT OF SEDIMENTS BY CHILDREN USING THE CENTRAL AREA

A. POTENTIAL CARCINOGENIC RISKS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE 27 kg CHILD, PRORATED OVER 70-YEAR LIFETIME (mg/kg/d)		POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Aldrin	1.65E-02	8.44E-02	7.18E-12	8.81E-10	1.72E-12	5.87E-10	8.90E-12	1.47E-09	1.70E+01	1.5E-10	2.5E-08
Arsenic	1.80E+02	4.65E+03	5.22E-07	1.08E-04	NQ	NQ	5.22E-07	1.08E-04	1.50E+00	7.8E-07	1.6E-04
Bis(2-ethylhexyl)phthalate	5.32E-01	1.34E+00	2.31E-10	1.40E-08	5.55E-11	9.32E-09	2.87E-10	2.33E-08	8.40E-03	2.4E-12	2.0E-10
Methylene chloride	1.05E-01	1.53E-01	3.04E-10	3.55E-09	3.65E-11	3.55E-09	3.41E-10	7.10E-09	7.50E-03	2.6E-12	5.3E-11
cPAHs (b)	5.44E+00	1.07E+01	2.37E-09	1.12E-07	5.68E-10	7.45E-08	2.93E-09	1.86E-07	1.15E+01	3.4E-08	2.1E-06
TOTAL										8E-07	2E-04

B. POTENTIAL NONCARCINOGENIC RISKS (a)

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)		QUANTITY OF CHEMICAL INGESTED AND ABSORBED VIA INGESTION (mg/kg/d)		QUANTITY OF CHEMICAL DERMALLY ABSORBED (mg/kg/d)		CHRONIC DAILY INTAKE (CDI), 27 kg CHILD (mg/kg/d)		REFERENCE DOSE RfD (mg/kg/d)	RATIO OF CDI:RfD	
	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM		AVERAGE	PLAUSIBLE MAXIMUM
Acetone	1.64E-01	3.90E-01	6.66E-09	1.27E-07	6.47E-07	1.27E-07	6.54E-07	2.53E-07	1.00E-01	6.5E-06	2.5E-06
Bis(2-ethylhexyl)phthalate	5.32E-01	1.34E+00	3.24E-09	1.96E-07	7.77E-10	1.31E-07	4.02E-09	3.26E-07	2.00E-02	2.0E-07	1.6E-05
Cadmium	2.17E+00	1.62E+01	8.81E-08	5.26E-06	NQ	NQ	8.81E-08	5.26E-06	5.00E-04	1.8E-04	1.1E-02
Chromium	1.04E+02	1.25E+03	4.22E-06	4.06E-04	NQ	NQ	4.22E-06	4.06E-04	5.00E-03	8.4E-04	8.1E-02
Copper	1.54E+02	3.01E+03	6.25E-06	9.77E-04	NQ	NQ	6.25E-06	9.77E-04	3.70E-02	1.7E-04	2.6E-02
Iron	1.90E+04	1.08E+05	7.71E-04	3.51E-02	NQ	NQ	7.71E-04	3.51E-02	1.00E+00	7.7E-04	3.5E-02
Lead	2.60E+01	1.20E+02	1.06E-06	3.90E-05	NQ	NQ	1.06E-06	3.90E-05	6.00E-04	1.8E-03	6.5E-02
Mercury	6.60E-01	2.99E+01	2.68E-08	9.71E-06	NQ	NQ	2.68E-08	9.71E-06	1.40E-03	1.9E-05	6.9E-03
Methylene chloride	1.05E-01	1.53E-01	4.26E-09	4.97E-08	4.14E-07	4.97E-08	4.19E-07	9.94E-08	6.00E-02	7.0E-06	1.7E-06
Nickel	1.31E+01	5.26E+01	5.32E-07	1.71E-05	NQ	NQ	5.32E-07	1.71E-05	2.00E-02	2.7E-05	8.5E-04
nPAHs (c)	2.76E+00	1.13E+01	1.68E-08	1.65E-06	4.03E-09	1.10E-06	2.08E-08	2.75E-06	4.10E-01	5.1E-08	6.7E-06
Zinc	7.39E+02	6.00E+03	3.00E-05	1.95E-03	NQ	NQ	3.00E-05	1.95E-03	2.10E-01	1.4E-04	9.3E-03
HAZARD INDEX										<1 (0.003)	<1 (0.2)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number).
A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).
(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
(b) Carcinogenic polynuclear aromatic hydrocarbons.
(c) Noncarcinogenic polynuclear aromatic hydrocarbons.
NQ = Not quantified; dermal absorption of inorganics is negligible.

individual is assumed to weigh 70 kg and drink 2 liters of water each day for 70 years (an average lifetime) (EPA 1985e). Based on these assumptions, and the existing chemical concentrations in the groundwater, chronic daily intakes were derived and are presented in Table 7-22. The risks associated with these intake levels are also presented for chemicals potentially exhibiting carcinogenic and noncarcinogenic effects.

The upper bound lifetime excess cancer risks associated with ingestion are $4x10^{-5}$ (i.e., four in one hundred thousand) and $3x10^{-4}$ (i.e., three in ten thousand) for the average and plausible maximum cases, respectively. The hazard index for the average exposure scenario is less than one indicating a low probability of adverse health effects. Under the plausible maximum exposure scenario, the hazard index is equal to one.

Exposure to the radionuclides were evaluated separately from the other contaminants detected in the central area groundwater. This is due to the fact that the procedures used to calculate risk are based on comparisons with acceptable levels determined by EPA (1986f, 1985f). In the Federal Register Notice (EPA 1986f), EPA proposed an acceptable yearly intake of 4 mrem/year of radionuclides. In the Drinking Water Criteria document, EPA (1985f) presented groundwater concentrations which correspond to this dose. These concentrations were used as a point of comparison. Table 7-23 summarizes the results. The geometric mean and maximum concentrations of gross alpha particles exceeds the reference concentration for radium-226. EPA (1986f) states that "radium-226 is responsible for about one-half of the gross alpha particle activity." The data collected at the Wells G & H site do not reflect this if the maximum gross alpha particle and radium concentrations are compared. Thus, it is more than likely that other radionuclides are present. The maximum gross beta particle concentration exceeds the concentration corresponding to a 4 mrem/year dose if all the gross beta particles are present as strontium-90. If, on the other hand, the gross beta particles are present as tritium, the concentrations are well below the concentrations corresponding to a 4 mrem/year dose. The maximum radium concentration exceeds the concentrations corresponding to 4 mrem/year. It should be noted that this concentration is exceeded by 4 pCi/liter and this could be due to analytical

TABLE 7-22

EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER FROM THE CENTRAL AREA

A. POTENTIAL CARCINOGENIC EFFECTS

	CONCENTRATION (ug/L)		CHRONIC DAILY INTAKE (mg/kg/d)			LIFETIME UPPER BOUND EXCESS CANCER RISK	
COMPOUND	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	AVERAGE	PLAUSIBLE MAXIMUM
Tetrachloroethene	26.8	180	7.66E-04	5.14E-03	5.10E-02	3.9E-05	2.6E-04
Trichloroethene	17.9	140	5.13E-04	4.00E-03	1.10E-02	5.6E-06	4.4E-05
TOTAL	--	--	--	--	--	4E-05	3E-04

B. NONCARCINOGENIC EFFECTS (a)

	CONCENTRATION (ug/L)		CHRONIC DAILY INTAKE (CDI) (mg/kg/d)			RATIO OF CDI:RfD	
COMPOUND	GEOMETRIC MEAN	MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	AVERAGE	PLAUSIBLE MAXIMUM
Barium	93.4	210	2.67E-03	6.00E-03	5.00E-02	5.3E-02	1.2E-01
trans-1,2-Dichloroethene	8.94	80	2.55E-04	2.29E-03	1.00E-02	2.6E-02	2.3E-01
Tetrachloroethene	26.8	180	7.66E-04	5.14E-03	2.00E-02	3.8E-02	2.6E-01
1,1,1-Trichloroethane	6.12	1700	1.75E-04	4.86E-02	9.00E-02	1.9E-03	5.4E-01
HAZARD INDEX	--	--	--	--	--	<1 (0.1)	1

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.
NA = Not applicable; mean not calculated with only one positive detection.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 7-23

EXPOSURES AND RISK ASSOCIATED WITH INGESTION OF RADIONUCLIDES PRESENT IN GROUNDWATER FROM THE CENTRAL AREA OF THE WELLS G & H SITE

COMPOUND	CONCENTRATION (pCi/L) GEOMETRIC MEAN	CONCENTRATION (pCi/L) MAXIMUM	REFERENCE CONCENTRATION (pCi/L) (a)	RISK CORRESPONDING TO REFERENCE CONCENTRATION	LIFETIME UPPER BOUND EXCESS CANCER RISK GEOMETRIC MEAN	LIFETIME UPPER BOUND EXCESS CANCER RISK MAXIMUM
Gross Alpha Particles	26	350				
- as Radium-226			1	1.00E-05	3E-04	4E-03
- as Radium-228			2	1.00E-05	1E-04	2E-03
Gross Beta Particles	30	180				
- as Strontium-90			46	8.00E-05	5E-05	3E-04
- as Tritium			88000	8.00E-05	3E-08	2E-07
Radium	2.2	14				
- as Radium-226			1	1.00E-05	2E-05	1E-04
- as Radium-228			2	1.00E-05	1E-05	7E-05
Uranium	2.4	4	7	1.00E-05	3E-06	6E-06

(a) Reference concentration corresponds to a dose corresponding to lifetime risk level for Radium-226, Radium-228, and Uranium or a dose corresponding to 4 mrem/year for Strontium-90 and Tritium.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

chemistry variability. The uranium concentration is well below the concentration corresponding to 4 mrem/year dose.

Inhalation of contaminants while showering - future-use scenario. In addition to ingestion of groundwater, inhalation of volatilized contaminants can occur while using the water for nonconsumptive uses. Exposure to individuals while showering is quantified here. The shower model of Foster and Chrostowski (1987), discussed in Section C.2 of Appendix C, was used to quantify exposure via this pathway. The potential health risks associated with the estimated inhalation exposures while showering are presented in Table 7-24. It should be noted that while the chronic daily intake for exposure to volatile organic contaminants in groundwater via ingestion and inhalation are comparable, as expected from the literature (Foster and Chrostowski 1987, McKone 1987, EPA 1984i), the risks from this exposure will vary due to differences in the potency factors. The excess lifetime upper bound cancer risks associated with the average and plausible maximum cases were $4x10^{-6}$ (i.e., four in one million) and $3x10^{-5}$ (i.e., three in one hundred thousand), respectively. For chemicals exhibiting noncarcinogenic effects, the individual CDI:RfD ratios for each compound under both the average and plausible maximum cases were below one as was the hazard index.

7.3.3 MULTIMEDIA EXPOSURES

Exposure via one of the pathways discussed above for the future-use scenarios does not preclude exposures via other pathways. For example, residents of the area may be exposed to contaminants in the groundwater via ingestion or inhalation. However, exposure by one route generally dominates the exposure and risk calculations, and by adding exposures from other routes is unlikely to have a substantial effect on risks. For example, under the average future-use scenario, the upper bound excess lifetime cancer risk associated with the inhalation of vapors released while showering is $4x10^{-6}$, and that associated with the ingestion of groundwater is $4x10^{-4}$. The sum of these two values is approximately equal to the risk value associated with ingestion of groundwater alone. Therefore, in this situation, the quantitative risk is determined by only one type of exposure.

TABLE 7-24

EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF VAPORS WHILE SHOWERING WITH GROUNDWATER FROM THE CENTRAL AREA OF THE WELLS G & H SITE

A. POTENTIAL CARCINOGENIC EFFECTS

COMPOUND	CHRONIC DAILY INTAKE (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (mg/kg/d) PLAUSIBLE MAXIMUM	POTENCY FACTOR (mg/kg/d)-1	LIFETIME UPPER BOUND EXCESS CANCER RISK AVERAGE	LIFETIME UPPER BOUND EXCESS CANCER RISK PLAUSIBLE MAXIMUM
Tetrachloroethene	5.58E-04	4.19E-03	3.30E-03	1.8E-06	1.4E-05
Trichloroethene	4.20E-04	3.52E-03	4.60E-03	1.9E-06	1.6E-05
TOTAL	--	--	--	4E-06	3E-05

B. NONCARCINOGENIC EFFECTS (a)

COMPOUND	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) AVERAGE	CHRONIC DAILY INTAKE (CDI) (mg/kg/d) PLAUSIBLE MAXIMUM	REFERENCE DOSE (RfD) (mg/kg/d)	RATIO OF CDI:RfD AVERAGE	RATIO OF CDI:RfD PLAUSIBLE MAXIMUM
trans-1,2-Dichloroethene	2.32E-04	2.24E-03	1.00E-02	2.3E-02	2.2E-01
Tetrachloroethene	5.58E-04	4.19E-03	2.00E-02	2.8E-02	2.1E-01
1,1,1-Trichloroethane	1.22E-04	4.31E-02	3.00E-01	4.1E-04	1.4E-01
HAZARD INDEX	--	--	--	<1 (0.05)	<1 (0.6)

(a) Noncarcinogens and potential carcinogens with RfDs were evaluated for noncarcinogenic risk.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

7.4 SUMMARY OF THE Central AREA OF THE WELLS G & H SITE EVALUATION

This section of the Endangerment Assessment for the central area of the Wells G & H site is a baseline assessment, which evaluates potential impacts to human health in the absence of further remedial actions under both current- and future-use scenarios. Chemicals of potential concern were selected based on the sampling data of the environmental media and consideration of toxicity. The soil chemicals of potential concern selected were cadmium, chlordane, lead, and pyrene. The groundwater chemicals of potential concern were barium, trans-1,2-dichloroethene, radionuclides (gross alpha and gross beta particles, radium, and uranium), tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene. The chemicals of potential concern for surface water were bis(2-ethylhexyl)phthalate, trans-1,2-dichloroethene, lead, tetrachloroethene, and trichloroethene. The sediment chemicals of concern were acetone, aldrin, arsenic, bis(2-ethylhexyl)phthalate, cadmium, chromium, copper, mercury, methylene chloride, carcinogenic PAHs, noncarcinogenic PAHs, and zinc.

Under current land-use conditions, the exposure pathways by which human receptors could potentially be exposed to site contaminants involve direct contact with soils, surface water, and sediment. Average and plausible maximum exposure scenarios were developed. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed populations. Human health risks were assessed based on estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of workers at the Riley Tannery to volatile released from water used in the production process could result in potential excess upper bound lifetime cancer risks of $2x10^{-6}$ for the average exposure case and $3x10^{-5}$ for the plausible maximum case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of individuals to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $2x10^{-9}$ for the average exposure case and $1x10^{-7}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are less than one.

- Exposure of adults trapping in the Aberjona River to surface water could result in potential upper bound excess cancer risks of $4x10^{-11}$ and $1x10^{-8}$ under average and plausible maximum exposure conditions, respectively. Exposure of this same population to sediments could result in potential upper bound excess cancer risks of $3x10^{-7}$ under average conditions and $4x10^{-4}$ under plausible maximum exposure conditions. The hazard indices were less than one for exposure to both surface water and sediments under average and plausible maximum conditions.

- Exposure to children playing the Aberjona River to surface water could result in potential upper bound excess cancer risks of $2x10^{-9}$ under average conditions and $6x10^{-8}$ under plausible maximum exposure conditions. Exposure of this same population to sediments could result in potential upper bound excess cancer risks of $8x10^{-7}$ and $2x10^{-4}$ under average and plausible maximum exposure cases, respectively. The hazard indices were less than one for exposure to both surface water and sediment for average and plausible maximum cases.

The exposure scenarios described above would apply for future land use conditions as well. In addition, exposure pathways related to groundwater use was considered. Average and plausible maximum exposure scenarios were developed for ingestion of groundwater and inhalation of volatiles while showering. The conclusions are summarized as follows:

- Ingestion of groundwater with the exception of the radionuclides could result in potential upper bound lifetime excess cancer risks of $4x10^{-4}$ and $5x10^{-3}$ for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average case but equaled 1 for the plausible maximum case.

- Ingestion of groundwater containing radionuclides could result in exposures greater than the recommended 4 mrem/year dose. The geometric mean and maximum gross alpha particle concentrations exceed this reference level. The maximum gross beta particles (as strontium 90) and radium concentrations exceed concentrations corresponding to a 4 mrem/year dose. If the gross beta particles are present as tritium, then the measured concentrations are much less than the concentration corresponding to a 4 mrem/year dose. The geometric mean and maximum uranium concentrations were both below the concentration corresponding to a 4 mrem/year dose.

- Inhalation of volatiles released from the groundwater while showering could result in $4x10^{-6}$ and $3x10^{-5}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average and plausible maximum cases.

8.0 ECOLOGICAL RISK ASSESSMENT

In addition to potential exposure of the human population discussed in earlier sections of this report, flora and fauna may also be exposed to contamination at the Wells G & H site. Chemicals present at the site may be toxic to plants and animals exposed to these substances via air, water, soil, sediment, or food. This section of the endangerment assessment identifies possible environmental receptors, addresses the potential pathways by which these receptors may be exposed to the chemicals of potential concern at the site, and estimates the risks to terrestrial and aquatic wildlife that may exist at the site.

The steps for the environmental assessment roughly parallel those for the human health risk assessments, in that information on exposure and toxicity are combined to generate an estimate of risk. However, the goal of human health risk assessment is protection of the individual. While protection of individual environmental receptors also may be important (e.g., the death of one individual of an endangered species), in most cases, an environmental risk assessment is focussed at the population level. Unfortunately, there is a paucity of toxicity data relevant to wildlife and it is difficult to draw inferences to the population level. For these reasons, wildlife risk assessments are qualitative to a large extent.

In the following sections, the potential impacts to fish and wildlife are assessed at the individual and population level. First, in Section 8.1, the chemicals of potential concern are discussed. In Section 8.2, the receptors potentially affected by chemicals associated with the Wells G & H site are identified. Potential exposure pathways are identified and exposure is quantified in Section 8.3. The methods used to assess toxicity data are discussed in Section 8.4 (toxicity data are summarized in Appendix D). In Section 8.5, the toxicity information is combined with estimates of exposure to provide an estimate of risk. In the final section, Section 8.6, the conclusions of this ecological risk assessment are presented.

8.1 CHEMICALS OF POTENTIAL CONCERN

The chemicals that will be evaluated in this environmental assessment are those chemicals detected frequently in surface water, sediment, soil, and sludge. Below, the chemicals of concern are discussed by media: surface water, sediment, and soil/sludge. In general, chemicals of potential concern were selected according to the guidelines summarized in Section 1.3 and Appendix A of this report.

The chemicals of concern for exposure to soils and sludges were selected according to the procedures outlined in Appendix A. The geometric mean concentrations of the inorganic constituents were compared with regional background values for inorganics in soil (as seen in Table A-1 of Appendix A). Chemicals were selected if geometric mean concentrations were twice maximum background values.

For surface water and sediments the procedures of Appendix A were used as a screening procedure. For sediments, the upstream sampling site and the regional soil values (as seen in Table A-1 of Appendix A) were used for background data. For surface water, the upstream sample was used for background data. After the screening criteria were met, the list of chemicals and their reported concentrations were reviewed based on the available toxicological data for effects on aquatic and terrestrial wildlife. Chemicals known to be of low toxicity except at extremely high concentrations were removed from further consideration. Examples of such chemicals are the following inorganics: barium, calcium, manganese, magnesium, potassium, and sodium. Volatile organic compounds found at several orders of magnitude below known toxic levels were also removed from further consideration.

For some of the chemicals of potential concern, there were insufficient toxicological data to assess risks. Data on toxicological effects to terrestrial wildlife were frequently lacking. Therefore, the assessment is limited to a discussion of the toxic effects of a subset of the chemicals of potential concern.

8.1.1 SURFACE WATER

The surface water sampling data are summarized in Table 8-1. The following chemicals, which were detected onsite, were removed from further consideration because maximum onsite concentrations did not exceed twice the maximum upstream (background) concentrations: 1,1-dichloroethane, 1,1,1-trichloroethane, arsenic, barium, calcium, copper, magnesium, manganese, potassium, sodium, and zinc. trans-1,2-Dichloroethene, trichloroethene, tetrachloroethane, and toluene were detected at low ug/liter concentrations which are 20-1000 times lower than concentrations reported to have produced effects in aquatic biota (EPA, 1986h). In addition, only trichloroethene was detected at the downstream station, which may indicate that substantial losses from the aquatic environment occur through volatilization. As a result of these observations, these four chemicals were removed from further consideration.

The other constituents detected in the surface water above background were selected as chemicals of potential concern. Thus, the chemicals of potential concern for surface water are: aluminum, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, di-n-octyl phthalate, iron, and lead.

8.1.2 SEDIMENTS

Sediment sampling data are summarized in Table 8-2. None of the detected volatile organic compounds were eliminated from consideration based on the initial comparison with upstream samples. Acetone, 2-butanone, and methylene chloride are selected as chemicals of potential concern. The other volatiles (benzene, toluene, 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethene, 1,2-dichloroethene, and vinyl chloride) were detected at concentrations of ≤ 5 ug/kg. Toxic effects in aquatic organisms have been observed at the hundreds to thousands of ug/liter level in water (EPA 1986h) for these compounds. No data were found linking these sediment concentrations with toxic effects. On the basis of these observations, these compounds are removed from further consideration.

TABLE 8-1

COMPOUNDS DETECTED IN SURFACE WATER AT THE CENTRAL AREA OF THE WELLS G & H SITE

COMPOUND	SITE			UPSTREAM			DOWNSTREAM		
ORGANICS (ug/L)	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
VOLATILES									
CHLOROFORM	ND			ND			1/3	NA	2.00
1,1-DICHLOROETHANE	2/24	NR	2.00	1/4	NA	2.00	ND		
TRANS-1,2-DICHLOROETHENE	2/24	4.18	22.0	ND			ND		
1,1,1-TRICHLORETHANE	13/22	3.48	8.00	3/4	4.30	10.0	ND		
TRICHLOROETHENE	5/24	2.71	26.0	1/3	NA	1.00	1/3	NA	0.50
TETRACHLOROETHENE	2/24	2.59	4.00	ND			ND		
TOLUENE	2/24	NR	1.00	ND			ND		
SEMI-VOLATILES									
BIS(2-ETHYLHEXYL)PHTHALATE	1/1	NA	100	1/1	NA	38.0	ND		
DI-N-OCTYL PHTHALATE	1/5	NA	5.00	ND			ND		
DI-N-BUTYL PHTHALATE	ND			ND			1/2	NA	1.00
BUTYLBENZYL PHTHALATE	2/5	5.90	29.0	1/1	NA	11.0	ND		
INORGANICS (ug/L)									
ALUMINUM	3/6	75.9	548	1/2	NA	25.0	2/3	247	396
ANTIMONY	ND			ND			1/3	NA	57.0
ARSENIC	4/6	5.45	8.80	1/2	NA	8.90	1/3	NA	6.10
BARIUM	5/6	26.0	46.0	2/2	25.5	27.0	3/3	18.1	27.0
BERYLLIUM	ND			1/1	NA	0.70	ND		
CADMIUM	ND			1/2	NA	6.00	ND		
CALCIUM	6/6	31600	43000	2/2	32900	39000	3/3	13300	28000
CHROMIUM	ND			1/2	NA	4.30	ND		
COPPER	2/5	NR	12.0	1/1	NA	10.0	3/3	12.7	17.0
IRON	6/6	1310	5200	2/2	712	1490	3/3	990	1050
LEAD	5/6	3.56	11.0	1/2	NA	2.20	3/3	7.83	20.0
MAGNESIUM	6/6	5090	8100	2/2	6140	7400	3/3	3980	4970
MANGANESE	6/6	377	460	2/2	408	480	3/3	129	230
POTASSIUM	6/6	4010	5700	2/2	4010	4700	3/3	2100	3460
SILVER	ND			1/2	NA	5.90	ND		
SODIUM	6/6	35700	70000	2/2	44000	59000	3/3	23700	33500
ZINC	6/6	141	190	2/2	183	196	3/3	99.2	192

NA = Not applicable; mean not calculated with only one positive detection.
ND = Not detected.
NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE THE GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

TABLE 8-2
COMPOUNDS DETECTED IN SEDIMENT AT THE CENTRAL AREA OF THE WELLS G & H SITE

CHEMICAL	SITE			UPSTREAM			DOWNSTREAM		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
ORGANICS (ug/kg)									
VOLATILES									
ACETONE	5/5	164	390	1/1	NA	39.9	3/4	34.5	395
2-BUTANONE	5/5	22.9	72.9	1/1	NA	12.2	1/4	NA	64.7
BENZENE	1/5	NA	4.50	ND			ND		
TOLUENE	4/5	2.22	3.10	ND			ND		
1,1-DICHLOROETHANE	1/5	NA	3.80	ND			ND		
1,1,1-TRICHLORETHANE	1/5	NA	2.80	ND			ND		
TRICHLOROETHENE	2/5	2.03	2.50	ND			ND		
1,2-DICHLOROETHENE	2/5	2.83	4.50	ND			1/4	NA	8.50
VINYL CHLORIDE	1/5	NA	5.00	ND			ND		
METHYLENE CHLORIDE	5/5	105	153	1/1	NA	27.6	4/4	8.15	315
BASE/NEUTRAL EXTRACTABLES									
ACENAPHTHENE	2/5	160	255	ND			2/4	78.0	194
ACENAPHTHYLENE	ND			ND			2/4	72.6	511
ANTHRACENE	3/5	195	606	1/1	NA	49.0	1/4	NA	949
BENZO(A)ANTHRACENE	3/5	439	2070	1/1	NA	314	4/4	36.3	4180
BENZO(A)PYRENE	3/5	426	1650	1/1	NA	283	2/4	149	3670
BENZO(B)FLUORANTHENE	3/5	511	1950	1/1	NA	314	1/4	NA	4210
BENZO(G,H,I)PERYLENE	3/5	271	568	1/1	NA	202	2/4	158	655
BENZO(K)FLUORANTHENE	3/5	410	1340	1/1	NA	298	3/4	87.2	4880
BIS(2-ETHYLHEXYL)PHTHALATE	4/5	532	1340	1/1	NA	246	1/4	NA	1630
BUTYL BENZYL PHTHALATE	ND			ND			1/4	NA	20.0
CHRYSENE	3/5	515	2100	1/1	NA	407	3/4	59.1	4610
DIBENZOFURAN	1/5	NA	115	ND			2/4	67.2	187
DIBENZO(A,H)ANTHRACENE	3/5	174	363	1/1	NA	89.6	1/4	NA	426
DI-N-BUTYL PHTHALATE	ND			ND			2/4	NR	8.00
DI-N-OCTYL PHTHALATE	ND			ND			1/4	NA	6.00
FLUORANTHENE	4/5	767	3990	1/1	NA	519	2/4	199	8150
FLUORENE	1/5	NA	247	ND			1/4	NA	514
INDENO(1,2,3-C,D)PYRENE	3/5	288	649	1/1	NA	163	2/4	159	913
2-METHYL NAPHTHALENE	ND			ND			1/4	NA	1.00
4-METHYLPHENOL	1/5	NA	168	ND			ND		
NAPHTHALENE	1/5	NA	89.1	ND			2/4	75.1	292
N-NITROSODIPHENYLAMINE	ND			ND			1/4	NA	747
PHENANTHRENE	3/5	487	2400	1/1	NA	160	3/4	74.4	3380
PYRENE	4/5	687	3740	1/1	NA	465	1/4	NA	7230
CARCINOGENIC PAHs, TOTAL	3/5	5440	10700	1/1	NA	1920	4/4	145	23800
NONCARCINOGENIC PAHs, TOTAL	4/5	2760	11300	1/1	NA	1350	3/4	247	20900

TABLE 8-2 (continued)
COMPOUNDS DETECTED IN SEDIMENT AT THE NONSOURCE AREA OF THE WELLS G & H SITE

CHEMICAL	SITE			UPSTREAM			DOWNSTREAM		
	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM	FREQ. OF DETECTION	GEOMETRIC MEAN	MAXIMUM
PESTICIDES/PCB'S									
ALDRIN	4/5	16.5	84.4	1/1	NA	12.1	ND		
4,4'-DDD	ND			ND			1/4	NA	26.9
INORGANICS (mg/Kg)									
ALUMINUM	17/17	9800	48800	3/3	3660	4320	4/4	13700	18400
ANTIMONY	1/17	NA	47.2	ND			ND		
ARSENIC	17/17	180	4650	3/3	16.3	24.0	4/4	121	325
BARIUM	17/17	33.8	192	3/3	12.3	20.9	4/4	53.3	69.0
BERYLLIUM	11/12	0.86	1.80	1/2	NA	0.29	ND		
CADMIUM	11/17	2.17	16.2	ND			1/4	NA	8.30
CALCIUM	17/17	3790	8550	3/3	1020	1290	4/4	4700	6840
CHROMIUM	17/17	104	1250	3/3	14.8	18.8	4/4	701	1560
COBALT	6/17	5.90	97.4	ND			3/4	8.84	17.0
COPPER	17/17	154	3010	3/3	19.4	25.0	4/4	433	641
IRON	17/17	19000	108000	3/3	9530	10200	4/4	27600	41100
LEAD	8/8	26.0	120	1/1	NA	75.0	3/3	251	349
MAGNESIUM	17/17	1500	5180	3/3	1810	2430	4/4	3610	4270
MANGANESE	17/17	302	11800	3/3	82.2	97.7	4/4	289	397
MERCURY	16/17	0.66	29.9	2/3	0.08	0.10	3/4	1.20	17.0
NICKEL	14/17	13.1	52.6	2/3	7.98	8.50	4/4	18.5	29.0
POTASSIUM	3/5	462	1030	ND			4/4	755	918
SELENIUM	11/16	1.06	36.5	ND			ND		
SODIUM	5/5	277	897	1/1	NA	145	4/4	416	618
THALLIUM	7/12	0.83	1.50	ND			ND		
VANADIUM	14/17	17.1	86.4	3/3	10.6	14.0	3/4	25.0	70.0
ZINC	17/17	739	6000	3/3	34.5	79.4	4/4	976	1520

NA = Not applicable; mean not calculated with only one positive detection.
ND = Not detected.
NR = Not reported; chemical was detected infrequently, and the use of one-half the detection limit in calculating a mean results in a mean concentration which exceeds the maximum detected value. Therefore a mean is not used.

#NOTE# DUE TO THE OCCASIONAL REJECTION OF SAMPLES DURING THE QA/QC PROCESS THE NUMBER OF SAMPLES USED TO CALCULATE A GEOMETRIC MEAN WILL SOMETIMES BE LESS THAN THE TOTAL NUMBER OF SAMPLES AS PRESENTED IN THE DENOMINATOR OF THE FREQUENCY OF DETECTION.

None of the base/neutral extractable organics were eliminated by the comparison with upstream samples and all are selected as chemicals of potential concern. Aldrin, which was found at elevated levels onsite and downstream, is also selected.

The inorganics eliminated by the initial screening were lead (based on background concentrations) and antimony (based on frequency of detection). The following inorganics were considered to be relatively nontoxic and were removed from consideration: barium, calcium, manganese, magnesium, potassium, and sodium.

The chemicals of potential concern for the sediments are: acetone, aldrin, arsenic, bis(2-ethylhexyl)phthalate, 2-butanone, cadmium, chromium, copper, iron, mercury, methylene chloride, 4-methylphenol, nickel, polycyclic aromatic hydrocarbons, selenium, and zinc.

8.1.3 SOIL/SLUDGES

Soil and sludge contaminants were considered for their potential risks to terrestrial plants and wildlife. The areas of concern are the Olympia Nominee Trust and Wildwood Conservation Corporation properties. These areas, which are relatively undeveloped and have a good vegetative cover, are likely to be good habitats for wildlife. The other properties, which are generally in more developed areas which wildlife would be less likely to frequent, will not be considered further. The sludge piles at Wildwood, which are not vegetated, are not likely to be frequented by wildlife and will not be considered further.

Sampling data are provided in Table 4-4 for the Olympia Nominee Trust property and Table 6-1 for the Wildwood Conservation Corporation property. Soil contaminants were selected as chemicals of concern based on the criteria described above. The chemicals of potential concern in soils are: acetone, bis(2-ethylhexyl) phthalate, chlordane, 4,4-DDT, trans-1,2-dichloroethene, methylene chloride, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, tetrachloroethene, toluene, and trichloroethene.

8.1.4 SUMMARY

Table 8-3 summarizes the chemicals of potential concern for each media for the environmental receptors at the Wells G & H site. The surface water chemicals of potential concern are aluminum, bis(2-ethylhexyl)phthalate, butylbenzyl phthalate, di-n-octyl phthalate, iron, and lead. The chemicals of potential concern for the sediments are acetone, aldrin, arsenic, bis(2-ethylhexyl) phthalate, 2-butanone, cadmium, chromium, copper, iron, mercury, methylene chloride, 4-methylphenol, nickel, polycyclic aromatic hydrocarbons, selenium, and zinc. The chemicals of potential concern for soils are acetone, bis(2-ethylhexyl) phthalate, chlordane, 4,4-DDT, trans-1,2-dichloroethene, methylene chloride, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, tetrachloroethene, toluene, and trichloroethene.

8.2 RECEPTOR CHARACTERIZATION

Receptors are the components of ecosystems that may be affected by contaminants. Because of the complexity of most natural systems, it is difficult to assess all of the potential impacts on all receptors for all chemical effects. This assessment selected specific subgroups of receptors and potential effects to act as surrogates in evaluating harm to the entire system.

The study area lies within the Aberjona River basin which is a sub-basin of the Mystic River watershed. The wetlands within the study area were identified by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) map of the site and from aerial photographs of the area (Alliance 1987). These wetlands help to store excess runoff during flood conditions which is then slowly released during drier periods (New England River Basins Commission 1975). Wetlands are also known to be excellent sediment traps since they intercept runoff-borne sediment before it enters groundwater, rivers, or lakes. In a wetland, the velocity of the surface

TABLE 8-3

Chemicals of Potential Concern to the Environmental Receptors
at the Wells G & H Site

Surface Water	Sediment	Soils
Aluminum	Acetone	Acetone
Bis(2-ethylhexyl)phthalate	Aldrin	Bis(2-ethylhexyl)phathlate
Butylbenzyl phthalate	Arsenic	Chlordane
Di-n-octyl phthalate	Bis(2-ethylhexyl)phthalate	4,4'-DDT
Iron	2-Butanone	trans-1,2-Dichloroethene
Lead	Cadmium	Methylene chloride
	Chromium	cPAHs[a]
	Copper	nPAHs[a]
	Iron	PCBs[b]
	Mercury	Tetrachloroethene
	Methylene chloride	Toluene
	4-Methylphenol	Trichloroethene
	Nickel	
	cPAHs[a]	
	nPAHs[a]	
	Selenium	
	Zinc	

[a] The polycyclic aromatic hydrocarbons were divided into two groups in the human health exposure and risk sections. These designations are used in this section for consistency rather than to imply any specific toxic response in environmental receptors.

[b] Polychlorinated biphenyls.

water is slowed, allowing for the deposition of the suspended particles from the water column. Additionally, the vegetation in the wetlands act as a screen, sieving the suspended sediment from the surface water. Vegetated wetlands have been shown to be excellent sediment traps that can retain and accumulate sediments for many years (Adamus 1983).

The Wells G & H site contains a 39 acre wetland described in part as a palustrine broad-leaved deciduous scrub-shrub/emergent wetland and in part as a palustrine broad-leaved deciduous forested wetland (Alliance 1987). There are also three smaller areas classified as palustrine emergent wetlands. The 39 acre wetland in the center of the site is heterogeneous in vegetation. The Wildwood Conservation Corporation and Olympia Nominee Trust properties to the west and south of the wetland are covered in old-field vegetation.

Wetlands areas are diverse habitats since they incorporate both aquatic and terrestrial species as well as those species which are amphibious. Lists of mammals, birds, reptiles and amphibians which could be present in the wetlands for this region were compiled by Alliance (1987) and are presented in Appendix F. Although the area surrounding the site is highly developed, the wetlands are in a portion of the site with very limited human activity.

The Aberjona River flows through the swamp just north of Olympia Avenue and then enters the large marsh. Common plant species found in the central marsh are emergent cattail, purple loosestrife, sedges, reeds and rushes. The edges of the marsh are ringed with red maple containing an understory of buckthorn, arrowwood, highbrush blueberry, and silky dogwood. A small island in the center of the marsh also contains red maple, but the understory is of winterberry, hobblebush, and red-osier dogwood. The northeast portion (about 3.6 acres) of the wetland is drier than the rest of the marsh and supports vegetation dominated by red maple with an understory of arrowwood, winterberry, highbush blueberry, shadbush, swamp azalea, and poison sumac. Mammals known to inhabit the area include woodchucks, raccoons, squirrels, and chipmunks. Birds include redwing blackbirds, yellowthroats, grackles, warblers, song sparrows, and ducks. Reptiles and amphibians are common representatives of marshes and here include turtles, snakes, and frogs. Insects are represented mainly by the orders Odonata (damsel- and dragonflies), Diptera (flies), Coleoptera (beetles), and Lepidoptera (moths and butterflies). No fish were observed in a limited investigation of the River and marsh performed by Alliance (1987).

Rare or endangered species are given special consideration in an environmental assessment. In non-threatened species, the loss of one individual may not influence the overall success of the population, as long as a constant breeding population is maintained. However, the loss of even one member of an endangered species may affect the chances of survival for the species. Thus, it is important to give particular attention to the potential occurrence of rare or endangered species near the site. A rare invertebrate, the Mystic Valley Amphipod (Crangonyx aberrans), which is on the State List of Rare Species, has been found in the area north of the site (Alliance 1987). While it has not been documented, it may use the Wells G & H site as a habitat. This organism, however, requires a high surface water flow rate for survival, and it is not known if the flow rate in the Aberjona River through the site is sufficient to support this species. The rare species, intricate fairy shrimp (Eubranchipus intricatus), may also inhabit the area, though again its presence is undocumented (Alliance 1987).

8.3 EXPOSURE ASSESSMENT

An exposure pathway consists of four elements: (1) a source and mechanism of chemical release to the environment, (2) an environmental transport medium (e.g., groundwater, surface water) for the released chemical, (3) a point of potential contact with the contaminated medium (the exposure point), and (4) an exposure route at the contact point. The sources of the chemicals at the Wells G & H site have been discussed earlier in this report. The release of these contaminants has resulted in soil, surface water, and sediment contamination which could affect the biota living at or near the site. The potential impact on environmental receptors from exposure to groundwater is limited. It is possible that, if the water table is sufficiently high, some plant roots may extend down into the groundwater; whether or not this occurs cannot be determined at this time and quantification is not possible. The only other impact from groundwater on environmental receptors is indirectly through discharge to the Aberjona River, as discussed in Appendix B of this report.

Exposure pathways are the routes by which an individual, population, community or ecosystem may encounter the chemicals of potential concern. Exposure pathways may be direct or indirect in nature. Direct pathways include direct contact or ingestion of contaminated media such as soil, sediment, water, or air. Indirect pathways, for the purposes of this assessment, are those in which an animal consumes other previously contaminated organisms. Some of the metals and organic compounds found at the Wells G & H site may bioaccumulate to some extent and therefore indirect exposure via the food chain may be possible. Identification of important pathways and their components is addressed in this section.

8.3.1 EXPOSURE OF AQUATIC LIFE

Aquatic biota may be exposed to chemical contaminants at the Wells G & H site in the Aberjona river and wetlands via contact with contaminated water and sediment and ingestion of contaminated food. Contaminated sediments of the Aberjona river and wetlands could serve as an exposure pathway for aquatic invertebrates which feed by extracting organic matter from ingested sediment.

The environmental transport and fate of the chemicals of potential concern for aquatic life influences the potential exposure of aquatic organisms. Because of the close interactions between surface water and sediment, a brief discussion of sediment-water interactions will be presented, and potential exposure to surface water and sediment will be discussed together. A more complete discussion can be found in Appendix B. In the risk characterization section of this environmental assessment, data from surface water and sediments will be evaluated separately to determine the potential for adverse effects to aquatic life from exposure to contaminants in each of the two media.

As is discussed in Appendix B, the concentrations of organic and inorganic compounds in surface water and sediments are governed by a partitioning mechanism which regulates the amount of the compound which will be adsorbed by the sediments and the amount remaining in the water. The sediments provide an important role in reducing the amount of a chemical available to the biota by acting as a "sink" for the chemical. If chemical concentrations in the water column are subsequently reduced, sediments may then act as a source by slowly releasing the sorbed compounds back into the water column. Other processes that may also influence the transfer rates between sediment and water and/or biota are storm events, sedimentation, and foraging movements of benthic organisms.

Food and other ingested debris are also sources for exposure to contaminants. The increase in chemical concentrations in an organism resulting from both bioconcentration directly from water into an organism, and from accumulation from other sources such as food and debris, is called <u>bioaccumulation</u>. When organisms eat other previously contaminated organisms they may be exposed to higher concentrations of a contaminant than are present in either surface water or sediment. This phenomenon is called <u>biomagnification</u>, since the concentration is increased or magnified up the food chain.

Bioconcentration of xenobiotics (chemicals which are foreign to living organisms) from the water column is also influenced by several environmental factors. One important factor in nutrient-rich systems such as marshes and wetlands is the amount of dissolved organic matter present in the water column. Dissolved organic matter, also referred to as dissolved organic carbon, is often measured as the fraction organic carbon (f_{oc}), reported as a percentage. Dissolved organic matter (e.g., fulvic acids, humic materials) is a ubiquitous component of freshwater systems and acts as a naturally occurring sorbent for many organic contaminants and metals (McCarthy and Black 1987). Dissolved organic matter can complex, or form bonds, with contaminants, thereby helping to stabilize them in the water column much as sediments act as sinks for xenobiotics. Complexation with dissolved organic matter has been shown to reduce the relative toxicity of compounds such as pesticides, PAHs and PCBs (McCarthy and Jimenez 1985, Landrum et al. 1985, Chiou et al. 1979), and some metals under certain conditions such as aluminum and copper (Driscoll et al. 1980, Baker 1982) by rendering them biologically unavailable. There is conflicting evidence, however, that indicates that dissolved organic matter may enhance the bioavailability of certain metals such as cadmium and lead (Besser and Rabeni 1987). The amount of organic carbon detected in sediments can be combined with an organic carbon partitioning coefficient (K_{oc}) to estimate an interstitial water concentration. This interstitial water concentration can then be used to estimate the exposure and resulting impact of nonpolar, hydrophobic organics to aquatic organisms. The potential hazards to aquatic life from exposure to surface water and sediment will be discussed in Section 8.5.1.

8.3.2 EXPOSURE OF PLANTS

Plants may be exposed to contaminants in air, soil, and water. Since phytotoxicity data, when available, generally link soil concentrations of contaminants with effects, the focus of the hazard assessment for plants will be on exposure to contaminants in soil.

8.3.3 EXPOSURE OF BIRDS

Birds may be exposed either directly or indirectly to contaminants at the Wells G & H site. Direct pathways for birds include ingestion of contaminants in sediments or water, and direct contact with contaminated soil or sediments. Some birds, such as the belted kingfisher (listed by Alliance (1987) as a possible inhabitant of the Wells G & H site), build their nests by burrowing into the soil along river bluffs and other exposed bank areas. Activities such as dust bathing, common among a number of bird species, also increase exposure to contaminated soil. Unfortunately, estimates of exposure via these pathways are not easily quantified due to the scarcity of data regarding the detailed activities of birds, and enormous variability of behavioral habits between species.

The potential exposure of birds from ingestion of contaminated water will be estimated. The daily water intake of birds has been estimated to be equivalent to 36% of body weight (Welty 1962). The American woodcock will be used as an indicator species to assess this potential route of exposure. A body weight of 0.17 kg is used based on weight data for bobwhite quail (USDA 1988). Bobwhite quail and woodcocks have approximately the same body length and robustness (Robbins et al. 1966). Chemical dosages (Table 8-4) are calculated by multiplying the onsite geometric mean surface water concentration by the number of kilograms of water ingested per day and then dividing by the body weight.

In this assessment, the potential risk associated with ingestion of contaminated aquatic invertebrates will be calculated for aquatic waterfowl which may utilize the wetland area. Dietary intakes are estimated by calculating the amount of food ingested each day and the concentration of chemical in the food. For the purposes of this assessment, it is assumed that chemicals accumulate only in the animal portion of the diet, although it is likely that some contaminants also accumulate in plants.

As discussed previously, aquatic invertebrates may bioaccumulate contaminants by (1) partitioning from the water column or (2) contact and/or ingestion of contaminated sediments. Unfortunately, adequate data are only available to estimate the contribution of the first route to invertebrate body burdens. Bioconcentration data are used in Table 8-5 in order to estimate body burdens of surface water contaminants in aquatic invertebrates that will be consumed by waterfowl. For the surface water chemicals of potential concern, the only chemical for which both bird toxicity data and bioconcentration data are available is lead. Therefore, the other chemicals of potential concern will not be assessed for this potential route of exposure.

The mallard, which was observed by a survey team at the marsh (Alliance 1987), is selected as an indicator species. To determine the dose for waterfowl at

TABLE 8-4

ESTIMATED EXPOSURE OF WILDLIFE FROM DRINKING OF SURFACE WATER CONTAMINANTS

Compound	Onsite Geometric Mean Surface Water Conc (ug/L)	Woodcock Dose (mg/kg/day)	Shrew Dose (mg/kg/day)
Aluminum	75.9	0.0272	1.50E-03
Bis(2-ethylhexyl)phthalate	100 (a)	0.0359	2.01E-03
Iron	1,310	0.470	0.0262
Lead	3.6	1.30E-03	7.11E-05

(a) Chemical was detected in one sample.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 8-5

ESTIMATED EXPOSURE OF WATERFOWL TO CONTAMINANTS FROM INGESTION OF AQUATIC INVERTEBRATES

Compound	Onsite Geometric Mean Surface Water Conc (mg/L)	Inveretbrate BCF	Estimated Invertebrate Conc (mg/kg)	Estimated Dose to Mallard (mg/kg/day)
Lead	3.6E-03	1,700 (a)	6.12	.0669

(a) Based on a 28-day test with the snail (Lymnaea palustris) as cited in EPA (1985g).

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

the Wells G & H site, it is assumed that a mallard (average weight--1.18 kg (Bellrose 1976)) consumes daily an amount of food equal to 10% of its body weight (J. Beevers, Wildlife International, Easton, MD, personal communication). Based on data of Martin et al. (1951) animals comprise about 11% of a mallard's diet averaged over a year. For this assessment it is assumed that the mallard's animal food consists entirely of aquatic invertebrates from the Aberjona River. The estimated animal food contaminant concentration is multiplied by the daily intake rate of 13.0 g/day to determine the daily amount (mg) of chemical ingested from animal food. This chemical intake is then divided by the body weight to determine an estimated dose in mg/kg/day (Table 8-5).

Birds may also ingest contaminated soil invertebrates such as earthworms. The importance of earthworms in terrestrial food webs has been reviewed by MacDonald (1983). Bioconcentration values (Table 8-6) for the uptake of contaminants by earthworms have been reported by Diercxsens et al. (1985) and Beyer and Gish (1980). For a number of chemicals no earthworm bioconcentration factors are available. A factor of 1 was assigned to these substances. The American woodcock is used as an indicator species for this potential route of exposure. Earthworms are assumed to comprise 70% of the diet of woodcocks (Sperry 1940 in DeGraaf and Rudis 1987). Daily food intake is estimated to be 34 g based on data for the bobwhite quail (USDA 1988). Dosages (Table 8-6) are calculated as described above for dietary ingestion of contaminants by waterfowl.

8.3.4 EXPOSURE OF MAMMALS

Since larger mammals, such as deer, were not observed or thought to occur onsite (Alliance 1987), exposure of small mammals such as shrews, raccoons, squirrels, mice, and rats will be assessed. These animals may be exposed to contaminants at the Wells G & H site via ingestion of food, water, or soil or via direct contact with contaminated media. For example, raccoons and skunks are known to prey on small rabbits and rodents and may be exposed to chemicals that have accumulated in these animals. Omnivorous or herbivorous mammals such as muskrats and rabbits could be exposed to chemicals of concern

TABLE 8-6

ESTIMATED EXPOSURE OF WILDLIFE TO OLYMPIA NOMINEE TRUST AND WILDWOOD CONSERVATION CORPORATION SURFACE SOIL CONTAMINANTS FROM INGESTION OF EARTHWORMS

		Olympia Nominee Trust Property			Wildwood Conservation Corporation Property		
Compound	Earthworm BCF (a)	Geometric Mean Soil Concentration (mg/kg)	Woodcock Dose (mg/kg/day)	Shrew Dose (f) (mg/kg/day)	Geometric Mean Soil Concentration (mg/kg)	Woodcock Dose (mg/kg/day)	Shrew Dose (f) (mg/kg/day)
Acetone	1 (b)	---	---	---	0.0814	0.0114	0.0063-0.00633
Bis(2-ethylhexyl)phthalate	1 (b)	---	---	---	0.407	0.0570	0.0317-0.317
Chlordane	1 (b)	---	---	---	0.0681	9.53E-03	0.0053-0.0530
DDTR	25.3 (c)	9.22E-03	0.0329	0.0183-0.183	0.0119	0.042	0.0236-0.236
trans-1,2-Dichloroethene	1 (b)	---	---	---	4.07E-03	5.70E-04	0.00032-0.00317
Methylene chloride	1 (b)	---	---	---	0.0221	3.19E-03	0.0017-0.0172
cPAHs (e)	1 (b)	0.0313	4.38E-03	0.0024-0.0243	1.10	0.154	0.0856-0.856
nPAHs (e)	1 (b)	0.0169	2.37E-03	0.0013-0.0131	0.713	0.0998	0.0555-0.555
PCBs (Aroclor 1254)	5.8 (d)	---	---	---	0.228	0.186	0.103-1.03
Tetrachloroethene	1 (b)	---	---	---	7.44E-03	1.04E-03	0.00058-0.00579
Toluene	1 (b)	---	---	---	6.21E-03	8.69E-04	0.00048-0.00483
Trichloroethene	1 (b)	---	---	---	0.0818	0.0115	0.00636-0.0636

(a) Earthworm BCF = (mg/kg wet weight earthworm / mg/kg dry weight soil)

(b) Assumed value.

(c) Beyer and Gish 1980 (converted to wet weight).

(d) Diercxsens et al. 1985.

(e) The polycyclic aromatic hydrocarbons were divided into two groups in the human health exposure and risk sections. These designations are used in this section for consistency rather than to imply any specific toxic response in environmental receptors.

(f) Shrew doses calculated for 10% and 100% earthworm diets.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified places to the left (i.e., 2.4E-03 = 0.0024).

by ingesting contaminated vegetation such as grasses and other small land plants. These mammals may also inadvertently ingest contaminated soil while feeding. Direct contact of contaminated soil could frequently occur among burrowing animals. Skunks dig and root in the soil while searching for insects and grubs. Rabbits and raccoons groom frequently and are likely to ingest contaminated soil while grooming. Unfortunately, the available data are not adequate to assess exposure via these pathways.

Mammals and other terrestrial organisms using the Aberjona River or the wetlands as a source of drinking water may be exposed to contaminants. Chemical concentrations found in the surface water will be used to assess potential impacts to mammals drinking from these waters. The shrew will be used as an indicator species for this potential route of exposure. The daily water intake is estimated to be 2% of body weight for the shrew. This value is based on a value of 3-4% determined in studies with laboratory rodents that received no dietary water (EPA 1985f). A body weight of 18 grams is used for shrews (USDA 1988) (Table 8-4).

The potential exposure of mammals to dietary contaminants will be assessed. The shrew will be used as an indicator species. Based on data in USDA (1988), shrews have an average body weight of 18 g and a daily dietary intake of 14 g/day. Values for exposure will be calculated for a worst case in which the diet is 100% earthworms and for a case in which the diet is 10% earthworms and 90% uncontaminated foods (Table 8-6).

8.4 TOXICITY ASSESSMENT

A brief description of the toxic effects of the site-related chemicals to biota is provided in Appendix D of this report. In addition, any available chemical-specific standards are identified.

The toxicity to aquatic biota of the chemicals of potential concern in surface water can be assessed using the ambient water quality criteria (AWQC) developed by EPA (1986h). These criteria are developed to protect 95% of all aquatic species. Maximum surface water concentrations are compared with acute AWQCs while geometric mean concentrations are compared with chronic AWQCs.

EPA is in the process of developing sediment quality criteria (SQC) for the protection of aquatic life exposed to contaminated sediment. Interim SQCs have been developed for nonpolar, hydrophobic organics by the Equilibrium Partitioning Approach (EPA 1988g). This approach assumes that (1) the toxicity and accumulation of contaminants by benthic organisms is correlated with the interstitial water concentration and (2) interstitial water concentrations are controlled by partioning between sediment and water. The fraction of organic carbon (f_{oc}) in the sediment must be known or estimated for this approach. For this assessment a value of 18.2%, which is the arithmetic mean value from 3 onsite sediment samples (EBASCO 1988a) will be used.

The interim sediment quality criteria (SQC) are estimated by the following equation:

$$SQC = K_{oc} * C_w * f_{oc}$$

where

SQC	=	normalized Sediment Quality Criteria (mg/kg);
K_{oc}	=	organic carbon partition coefficient (liter/kg);
C_w	=	interstitial water concentration (mg/liter) which is expected to be protective of aquatic life (e.g. the AWQC); and
f_{oc}	=	fraction organic carbon.

These SQC, normalized for the fraction organic carbon, are compared with the sediment concentrations in the same way that AWQC are compared with surface water concentrations to estimate potential hazard. SQC for metals are currently being developed by EPA. In the absence of any approved approach, the hazards of sediment metal concentrations will be discussed in relation to invertebrate sediment bioassay data.

Toxicity reference values (TRVs) (Table 8-7) will be used to assess the risks of exposures of terrestrial plants, birds, and wildlife to contaminants at the

TABLE 8-7

SUMMARY OF TOXICITY REFERENCE VALUES (TRVs) FOR BIRDS AND MAMMALS (a)

Compound	Avian TRV (mg/kg)	Mammalian TRV (mg/kg/day)
Acetone	NA	10 (c)
Aluminum	NA	0.025 (c)
Bis(2-ethylhexyl)phthalate	NA	1.9 (c)
Chlordane	2.8 (b)	0.0045 (c)
DDTr	0.0375 (c)	0.005 (c)
trans-1,2-Dichloroethene	NA	1.7 (c)
Iron	NA	NA (c)
Lead	0.312 (c)	0.005 (c)
Methylene chloride	NA	5.85 (c)
cPAHs (based on benzo[a]pyrene) (d)	NA	2E-04 (c)
nPAHs (based on naphthalene) (d)	NA	NA
PCBs (Aroclor 1254)	0.375 (c)	1.5E-04 (c)
Tetrachloroethene	NA	1.4 (c)
Toluene	NA	NA
Trichloroethene	NA	NA

(a) References and/or calculations for the TRVs are given in Appendix D.

(b) Based on acute toxicity data.

(c) Based on subchronic or chronic toxicity data.

(d) The polycyclic aromatic hydrocarbons were divided into two groups in the human health exposure and risk sections. These designations are used in this section for consistency rather than to imply any specific toxic response in environmental receptors.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

site. For terrestrial plants, phytotoxicity data will be compared against soil concentration data. Whenever possible no observed effect levels (NOELs) will be used.

For birds, toxicity data from laboratory studies will be compared with exposure data. Information on chronic or subchronic toxicity will be used whenever available. For those compounds for which only acute lethality values for birds are available, toxicity values will be derived by dividing lethality data by an uncertainty factor. In evaluating the potential effects of pesticides on birds, this risk assessment adopts the EPA assumption that there is no acute hazard if the estimated dose is less than one-fifth of the LD_{50} for nonendangered species (Urban and Cook 1986). Therefore, acute toxicity values are derived for birds by dividing the LD_{50} by 5. Note that this approach does not include assessment of chronic toxicity. A safety factor of 10 is applied when bird TRVs are derived from subchronic rather than chronic toxicity data. A safety factor of 10 is also applied if data describe a lowest observed effect level (LOEL) rather than a NOEL. These safety factors are similar to those applied in the derivation of human health criteria.

For terrestrial wildlife, the toxicity assessment will focus on effects on mammals since there are generally few data on the effects of contaminants on reptiles and amphibians. TRVs will be based on chronic studies in terrestrial mammalian wildlife whenever possible. Since there are few data for the chronic effects of contaminants on wild species of mammals, laboratory rodent and human studies will often be used as the basis for the TRVs. Studies used by the EPA in determining chronic oral reference doses (RfDs) (defined in Appendix D) will be used as the bases for the TRVs, when such data exist. In general, these studies will provide NOELs from chronic studies with laboratory rodents. Safety factors of 10 will be applied when such data are LOELs rather than NOELs and when subchronic rather than chronic studies are used.

8.5 RISK CHARACTERIZATION

The environmental receptors discussed in Section 8.2 may be exposed to chemicals present in the Aberjona River, wetlands, and land at the Wells G & H site via surface water, sediments, and soils. This assessment is structured around the potential toxicity of the chemicals of potential concern and the selected potential receptors identified above.

8.5.1 RISKS TO FISH AND AQUATIC LIFE

8.5.1.1 Surface Water

Potential risks to aquatic life are estimated by comparing the measured surface water concentration with the AWQC or the selected toxicity value for each chemical of concern. Average surface water concentrations are compared with chronic (4-day average) criteria, and maximum surface water concentrations are compared with acute (1-hour maximum) criteria in Table 8-8. For the contaminants for which no AWQC exist, these surface water concentrations are compared with measured or estimated chronic and acute toxicity values (preferably NOELs or LOELs) obtained from the literature. Chemicals at concentrations that equal or exceed the LOELs, or exceed the NOELs, may pose an increased risk to the aquatic life of the area.

For the phthalates, EPA (1986h) reported a chronic LOEL of 3 ug/liter. This value is exceeded by the geometric mean concentration onsite (5.9 ug/liter) for butylbenzyl phthalate. Bis(2-ethylhexyl) phthalate (38 ug/liter upstream; 100 ug/liter onsite) and di-n-octyl phthalate (5.0 ug/liter onsite) also exceeded this value. No mean values were available because these compounds were only detected once at each site.

The chronic AWQC of 87 ug/liter for aluminum (EPA 1986h) was exceeded at the downstream site (geometric mean of 247 ug/liter). For iron, EPA (1986h) issued an advisory value of 1000 ug/liter for acute and chronic effects. This value was exceeded at all three sampling sites. Iron and aluminum are the

TABLE 8-8

Comparison of Surface Water Concentrations With Ambient Water Quality Criteria (AWQC)

	Chronic AWQC (ug/liter)	Geometric Mean Surface Water Concentrations (ug/liter)			Acute AWQC (ug/liter)	Maximum Surface Water Concentrations (ug/liter)		
		Upstream	Site	Downstream		Upstream	Site	Downstream
Semivolatiles								
Bis(2-ethylhexyl)phthalate	3	NC	NC	ND	940	38	100	ND
Di-n-octyl phthalate	3	ND	NC	ND	940	ND	5	ND
Butylbenzyl phthalate	3	NC	5.9	ND	940	11	29	ND
Inorganics								
Aluminum	87	NC	75.9	247	750	25	548	396
Iron	1000	712	1310	990	1000	1490	5200	1050
Lead	4.5 (a)	NC	3.6	7.8	115 (a)	2.2	11	20

(a) Based on a calculated hardness of 131 mg/L as $CaCO_3$ for surface water at the site.
Hardness (mg/L $CaCO_3$) = 50 (A/20.04+B/12.16) where A = $[Ca^{++}]$mg/L; B = $[Mg^{++}]$mg/L.
ND = Not detected.
NA = Not available.
NC = Not calculated. Geometric mean not estimated when only one detected.

second and third most abundant metals in the earth's crust, respectively (Hem 1985); it is likely that concentrations found in the river are due to naturally occurring conditions with the source of these constituents being the clay and peat present in river sediments rather than anthropogenic inputs related to the site. Additionally, the presence of peat can act to keep these elements dissolved in river water at higher levels than expected based on strict physical and chemical properties of the elements (Stevenson 1982).

The chronic AWQC for lead is 4.5 ug/liter based on a calculated water hardness of 131 mg $CaCO_3$/liter for the onsite station. This value was exceeded at the downstream site where the geometric mean value was 7.8 ug/liter.

These data indicate that contaminants are present at all three sites in excess of EPA criteria levels. Levels of these contaminants were generally higher at the site and downstream stations. In most cases, these levels have been reported to cause chronically rather than acutely toxic effects.

8.5.1.2 Sediments

The potential risks to aquatic life from nonpolar, hydrophobic organics can be estimated by comparing geometric mean sediment concentrations with SQCs normalized for organic carbon content (Table 8-9). None of the SQCs are exceeded. Sediment concentrations are 16-28,000 times lower than the SQCs. No SQCs are available for the other organic compounds or for the metals detected in the sediments.

The risks of metal contaminants in sediments can be assessed by comparing onsite concentrations with concentrations tested in laboratory bioassays. Few laboratory studies measure sediment metal concentrations. Such comparisons are further complicated by differences in sediment f_{oc}, pH, and redox potential which affect the bioavailability and toxicity of metals (Hamelink 1980; Besser and Rabeni 1987). In a laboratory study, Cairns et al. (1984) reported that 10-day LC_{50}s for aquatic invertebrates ranged from 857 to 2,296 mg copper/kg sediment. For Daphnia magna, these authors reported 2-day LC_{50}s

TABLE 8-9

Comparison of Geometric Mean Sediment Concentrations
With Sediment Quality Criteria

Compound	Geometric Mean Sediment Concentration (mg/kg) Upstream	Site	Downstream	Koc (l/kg)	Ambient Water Quality Criteria or Other Value (a) (mg/l)	Sediment Quality Criteria (mg/kg) (b)
Acenapthene	ND	0.16	0.078	12882	0.057	133.6
Acenaphthylene	ND	ND	0.0726	6457	0.0012	1.4
Aldrin	NA	0.0165	ND	40738	0.003	22.2
Anthracene	NA	0.195	NA	14454	0.0012	3.2
Benzo(a)anthracene	NA	0.439	0.0363	436516	0.003	238.3
Benzo(a)pyrene	NA	0.426	0.149	891251	0.0012	194.6
Benzo(b)fluoranthene	NA	0.511	NA	1445440	0.0012	315.7
Benzo(g,h,i)perylene	NA	0.271	0.158	5888437	0.0012	1286.0
Benzo(k)fluoranthene	NA	0.41	0.0872	2511886	0.0012	548.6
Bis(2-ethylhexyl)phthalate	NA	0.532	NA	87100	0.940	14901.1
Chrysene	NA	0.515	0.0591	177828	0.0012	38.8
Dibenzo(a,h)anthracene	NA	0.174	NA	389045	0.0012	85.0
Fluoranthene	NA	0.767	1.991	144544	0.013	342.0
Indeno(1,2,3-c,d)pyrene	NA	0.288	0.159	14791084	0.0012	3230.4
Naphthalene	ND	NA	0.0751	1413	0.62	159.4
Phenanthrene	NA	0.487	0.0744	22387	0.0063	25.7
Pyrene	NA	0.687	NA	100000	0.013	236.6

NA = Not applicable; mean not calculated with only on positive detection.

ND = Not detected.

(a) For PAHs where no toxicity data are available, the value for benzo(a)pyrene is substituted to obtain a rough estimate of a sediment quality criteria (SQC) for comparison.

(b) Obtained by multiplying AWQC or other toxicity value first by the organic carbon partitioning coefficient (Koc) and then by the fraction organic carbon (18.2%).

of 681 and 937 mg/kg. The geometric mean and maximum onsite copper sediment concentrations were 154 and 3010 mg/kg, respectively. The laboratory studies were performed in sediments with 1.8% and 3.0% f_{oc} while the site sediment averaged 18.2% f_{oc}. Such differences may strongly influence bioavailability and toxicity. Nevertheless, the presence of copper at its maximum concentration does exceed these LC_{50} values and may pose a hazard to aquatic invertebrates. No similar laboratory data were found for the other metals detected in the site sediment.

In a limited ecological investigation of Wells G & H , Alliance (1987) reported a decrease in both species numbers and abundance of Aberjona River invertebrates onsite when compared to areas not expected to be impacted by the site. Stressed natural communities will typically show a decrease in species richness (number of species) due to a loss of the most sensitive species. At a number of sites in the Aberjona River and wetlands, Alliance (1987) reported few or no aquatic invertebrates. In other sites, the community was dominated by tubificid worms, which have been reported to be tolerant of polluted conditions (Alliance 1987).

Samples taken from an area of the Aberjona River (SD-6 in Figure 7-3) had highly elevated (above background) levels of arsenic, chromium, copper, and zinc. In 1987 sediment samples, concentrations of these metals were 3630 mg/kg, 1250 mg/kg, 3010 mg/kg, and 5170 mg/kg, respectively. Three samples were taken from this area in 1988. Maximum 1988 concentrations were 732 mg/kg for arsenic, 778 mg/kg for chromium, 1260 mg/kg for copper, and 6000 mg/kg for zinc. Maximum background sediment concentrations were 24 mg/kg for arsenic, 18.8 mg/kg for chromium, 25 mg/kg for copper, and 79.4 mg/kg for zinc. In this area of the Aberjona River, Alliance (1987) found extremely low abundances of invertebrates with few species represented. No zooplankton were found. The small numbers of amphipods that were observed were reported to be "half the size" of amphipods found at other sites.

On the basis of the ecological investigation and the sampling data, it is likely that the aquatic invertebrate community is being stressed by the presence of contaminants. Quantification of the potential for most of the sediment-bound metals to bioaccumulate or cause toxic effects in aquatic biota is not possible.

8.5.2 RISKS TO TERRESTRIAL SPECIES

This section will discuss risks to plants, birds, and mammals that may inhabit the Wells G & H site.

8.5.2.1 Risks to Plants

The geometric mean concentrations of chemicals of potential concern in soils at the Olympia Nominee Trust and Wildwood Conservation Corporation properties are compared with known phytotoxic concentrations in Table 8-10. None of the chemicals of concern were present at concentrations exceeding the plant toxicity reference values.

8.5.2.2 Risks to Terrestrial Wildlife

Birds - Drinking of Surface Water. The exposure (Table 8-4) and risks (Table 8-11) of birds to contaminants by drinking surface water are estimated. Bird TRVs were only available for lead. In this case the estimated dose is about 0.4% of the TRV. Thus, this potential route of exposure does not appear to pose a risk to birds.

Waterfowl - Dietary Contaminants. The estimated exposure of the mallard to lead bioconcentrated by invertebrates is 0.0669 mg/kg/day as seen in Table 8-5. This value is approximately 21% of the bird TRV of 0.312 mg/kg/day (Table 8-12). However, it was not possible to quantify the contribution of lead or other metals in the Aberjona River sediments to the body burden in aquatic invertebrates. In the absence of invertebrate body burden data, it is not possible to firmly conclude that there is no risk to waterfowl from dietary contaminants.

TABLE 8-10

RISKS TO PLANTS FROM CONTAMINANTS IN SURFACE SOILS AT THE OLYMPIA NOMINEE TRUST AND WILDWOOD CONSERVATION CORPORATION PROPERTIES

Chemical	Geometric Mean Soil Concentration (mg/kg) Olympia	Geometric Mean Soil Concentration (mg/kg) Wildwood	Plant Toxicity Reference Value (mg/kg)
Acetone	---	0.0814	NA
Bis(2-ethylhexyl)phthalate	---	0.407	200 (a) (b)
Chlordane	---	0.0681	NA
DDTr	9.22E-03	0.0119	12.5 (c)
trans-1,2-Dichloroethene	---	4.07E-03	NA
Methylene chloride	---	0.0221	NA
cPAHs (d)	0.0313	1.1	NA
nPAHs (d)	0.0169	0.713	NA
Pentachlorophenol	---	---	NA
Phenol	---	---	NA
PCBs (e)	---	0.228	2.5 (a)
Tetrachloroethene	---	7.44E-03	NA
Toluene	---	6.21E-03	NA
Trichloroethene	---	0.0818	NA

(a) No observed effect level.

(b) Based on data for di-n-butyl phthalate.

(c) Lowest observed effect level (LOEL).

(d) The polycyclic aromatic hydrocarbons were divided into two groups in the human health exposure and risk sections. These designations are used in this section for consistency rather than to imply any specific toxic response in environmental receptors.

(e) Polychlorinated biphenyls.

NA = Insufficient information available.

NOTE: Scientific notation (such as 2E-06) is a shorthanded way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 8-11

RISKS TO WILDLIFE FROM DRINKING OF SURFACE WATER CONTAMINANTS

Chemical	Estimated Woodcock Dose (mg/kg/day)	Bird TRV (a) (mg/kg/day)	Estimated Shrew Dose (mg/kg/day)	Mammalian TRV (a) (mg/kg/day)
Aluminum	0.0272	NA	1.50E-03	0.025
Bis(2-ethylhexyl)phthalate	0.0359	NA	2.01E-03	1.9
Iron	0.470	NA	0.0262	NA
Lead	1.30E-03	0.312	7.11E-05	0.005

(a) Toxicity Reference Value - see text and Table 8-7 for derivation.

NA = Insufficient information available.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

TABLE 8-12

RISKS TO WATERFOWL FROM INGESTION OF CONTAMINANTS IN INVERTEBRATES

Chemical	Estimated Dosage to Mallard (mg/kg/day)	Bird TRV (a)
Lead	0.0669	0.312

(a) Toxicity Reference Value - see text and Table 8-7 for derivation.

Birds - Ingestion of Earthworms from Contaminated Soils. Estimated exposures to birds through this potential route of exposure are given in Table 8-6 for the Olympia Nominee Trust and Wildwood Conservation Corporation properties. Risks are given in Tables 8-13 for the Olympia Nominee Trust property and Table 8-14 for the Wildwood Conservation Corporation property.

The presence of elevated levels of DDT residues (DDTr) and PCBs in surface soils may pose a risk to birds through this potential route of exposure. At Olympia, the estimated dose of DDTr is slightly less than the TRV. At the Wildwood Conservation Corporation property, the estimated dose of DDTr slightly exceeds the TRV, while the estimated dose of PCBs is about half the TRV.

PCBs and DDT are highly persistent in the environment and have been shown to bioaccumulate in terrestrial food chains. Thus, beside posing a risk to birds that directly consume earthworms, these contaminants may be passed on to predators and scavengers. There are numerous studies relating DDT and PCBs to effects such as reduced eggshell thickness, reduced fecundity, and an overall decline in reproductive capacity and survival (Murphy 1980; Eisler 1986). It is concluded that the presence of these contaminants in surface soils at the Olympia Nominee Trust and Wildwood Conservation Corporation properties may pose a risk to bird populations.

Mammals - Drinking of Surface Water. The exposure (Table 8-4) and risks (Table 8-11) of this potential route of exposure are evaluated. Mammalian TRVs were available for aluminum, bis(2-ethylhexyl)phthalate, and lead. For aluminum the estimated dose was 6% of the TRV. For bis(2-ethylhexyl) phthalate the estimated dose was about 0.1% of the TRV, while for lead the estimated dose was about 1.4% of the TRV. This potential route of exposure does not appear to pose a risk to mammalian wildlife.

Mammals - Ingestion of Earthworms from Contaminated Soils. Estimated exposures of mammals through this potential route are given in Table 8-6. A range is given in order to estimate doses for worst case (100% earthworm) and

TABLE 8-13

RISKS TO WILDLIFE FROM INGESTION OF CONTAMINANTS IN EARTHWORMS IN OLYMPIA NOMINEE TRUST PROPERTY SURFACE SOILS

Chemical	Estimated Woodcock Dose (mg/kg/day)	Bird TRV (a) (mg/kg)	Range of Estimated Shrew Doses (mg/kg/day)	Mammalian TRV (a) (mg/kg/day)
DDTr	0.0329	.0375	0.0183-0.183*	0.005
cPAHs (c)	4.38E-3	NA	0.0024-0.0243*	2E-4 (b)
nPAHs (c)	2.37E-3	NA	0.0013-0.0131	NA

(a) Toxicity Reference Value - see text and Table 8-7 for derivation.

(b) Value for benzo(a)pyrene.

(c) The polycyclic aromatic hydrocarbons were divided into two groups in the human health exposure and risk sections. These designations are used in this section for consistency rather than to imply any specific toxic response in environmental receptors.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

NA = Insufficient information available.

* = Exceeds TRV.

TABLE 8-14

RISKS TO WILDLIFE FROM INGESTION OF CONTAMINANTS IN EARTHWORMS IN WILDWOOD SURFACE SOILS

Chemical	Estimated Woodcock Dose (mg/kg/day)	Bird TRV (a) (mg/kg)	Range of Estimated Shrew Doses (mg/kg/day)	Mammalian TRV (a) (mg/kg/day)
Acetone	0.0114	NA	0.0063-0.0633	1
Bis(2-ethylhexyl)phthalate	0.0570	NA	0.0317-0.317	1.9
Chlordane	9.53E-03	2.8	0.0053-0.0530 *	4.5E-03
DDTr	0.042 *	0.0375	0.0236-0.236 *	5E-03
trans-1,2-Dichloroethene	5.70E-04	NA	0.00032-0.00317	1.7
Methylene chloride	3.19E-03	NA	0.00172-0.0172	5.85
cPAHs (c)	0.154	NA	0.0856-0.856 *	2E-04 (b)
nPAHs (c)	0.0998	NA	0.0555-0.555	NA
PCBs (d)	0.186	0.375	0.103-1.03 *	1.5E-04
Tetrachloroethene	1.04E-03	NA	0.00058-0.00579	1.4
Toluene	8.69E-04	NA	0.00048-0.00483	NA
Trichloroethene	0.0115	NA	0.00636-0.0636	NA

(a) Toxicity Reference Value - see text and Table 8-7 for derivation.

(b) Value for benzo(a)pyrene.

(c) The polycyclic aromatic hydrocarbons were divided into two groups in the human health exposure and risk sections. These designations are used in this section for consistency rather than to imply any specific toxic response in environmental receptors.

(d) Polychlorinated biphenyls.

NA = Insufficient information available.

* = Exceeds TRV.

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2.4E-03 = 0.0024).

lesser case (10% earthworm) diets. Risks for the Olympia Nominee Trust and Wildwood Conservation Corporation properties are given in Tables 8-13 and 8-14, respectively. For the Olympia Nominee Trust property, the estimated doses for DDT and cPAHs exceed the TRVs. For Wildwood Conservation Corporation property, the estimated doses for chlordane, DDTr, cPAHs, and PCBs exceed the TRVs. For nearly all of these contaminants, the estimated doses from the 10% earthworm diet exceeds the TRVs by at least a factor of 10. The health effects of these substances are summarized in Appendix D. On the basis of this risk assessment, it is concluded that the presence of these chemicals in surface soils at the Olympia Nominee Trust and Wildwood Conservation Corporation properties is likely to pose a chronic risk to wild mammal populations.

8.5.3 RISKS TO RARE SPECIES

Insufficient information is available to determine the presence of two rare crustacean species within the site boundaries.

8.6 SUMMARY AND CONCLUSIONS

Potential risks to environmental receptors have been evaluated based on the results of site monitoring data, a review of the toxicity of the chemicals of concern, and estimates of exposure. The assumptions used in estimating exposures and deriving toxicity reference values have been described in this assessment. The results of this environmental risk assessment are summarized below.

Aquatic life may be at risk from exposure to aluminum, iron, lead, and three phthalates (bis(2-ethylhexyl)-, butylbenzyl-, and di-n-octyl phthalate) in surface water. Concentrations reported at the site and downstream exceeded chronic AWQCs. The concentrations of aluminum and iron, however, are unlikely to have resulted from site-related anthropogenic inputs. The presence of the phthalates could be due to laboratory contamination rather than due to site-related activities. All of the contaminants in surface water were detected at concentrations associated with chronic rather than acute toxicity.

The maximum concentration of copper reported in the site sediments exceeds laboratory LC_{50} concentrations for several invertebrate species. Levels of arsenic, chromium, and zinc were elevated above background but conclusions cannot be drawn due to a lack of data linking sediment concentrations with effects. Qualitative field observations of decreases in abundance and diversity of aquatic invertebrates also suggest adverse conditions for aquatic life.

Waterfowl in the Aberjona River and marsh areas may obtain contaminants through their consumption of aquatic invertebrates. The ingestion of lead that has been bioconcentrated by invertebrates does not appear to pose a substantial risk to ducks. No conclusions can be made on the risks to waterfowl from ingestion of contaminated invertebrates in the absence of body burden data for either invertebrates or waterfowl.

Terrestrial birds and mammals can obtain contaminants by drinking surface water at the site. However, the levels of contaminants obtained through this route are much lower than known toxic levels, and significant risks are not expected from this route of exposure.

Some species of birds, such as woodcocks which feed predominantly on earthworms, may obtain potentially hazardous doses DDT and PCBs. The persistence of DDTr and PCBs in terrestrial ecosystems is cause for concern that predators and scavengers may also be adversely affected.

Mammals such as the shrew, which also consume large number of earthworms, may be at risk. Chlordane, DDTr, PAHs and PCBs are the chemicals of concern. These substances are known to cause chronic toxic effects in laboratory rodents. In most cases, estimated doses exceeded toxicity reference values by at least a factor of 10.

9.0 UNCERTAINTIES IN RISK ASSESSMENT

The procedures and inputs used to assess risks in this evaluation, as in all such assessments, are subject to a wide variety of uncertainties. In general, there are the following main sources of uncertainty:

- Environmental chemistry sampling and analysis
- Environmental parameter measurement
- Fate and transport modeling
- Exposure parameter estimation
- Toxicological data

Uncertainty in environmental sampling arises in part from the potentially uneven distributions of chemicals in the media samples. Typically, this problem is encountered more frequently in soil than water or air. The collection of grab samples allows an estimate of the variation in the chemical concentration in the area to be made. Compositing samples is considered to provide a good estimate of the average chemical concentrations in the area sampled. However, it may act to dilute hot spots and thus lead to an underestimation of maximum plausible exposures.

Environmental chemistry analysis error can stem from several sources including the errors inherent in the analytical methods, chain of custody problems, or the characteristics of the matrix being sampled. Procedural or systematic error was minimized by subjecting EPA collected data to a strict laboratory quality control review and data validation process. In the case of groundwater samples collected at the Unifirst Property, data collected by both EPA and Unifirst were used in this Endangerment Assessment. Only EPA collected soil data were used. Based on the data validation, no data were considered unusable with the exception of data qualified with an "R" indicating a rejected value, other data were qualified but were considered useable. For example, some of the samples were qualified during validation as being an estimated value. These concentrations were subsequently used to calculate geometric means and in some cases, were the maximum value detected. Hence, risks calculated using these results may be under- or overestimated.

Another analytical problem potentially affecting the risk assessment concerns the sample detection limits attained for the chemicals of concern at the Wells G & H site. Although certain chemicals were not detected in groundwater or soils and sediments at the Wells G & H site, the sample detection limits may have been higher than either ARARs or levels indicative of significant risk. It is uncertain, therefore, whether these chemicals are present above or below a level of concern in these media at the Wells G & H site. If these chemicals were present at levels below the detection limit but above the levels of concern, exclusion of these chemicals from the risk assessment would underestimate the risks associated with certain exposures. If, on the other hand, chemical concentrations are below both the detection limit and the levels of concern, their exclusion would not significantly impact the risk estimates.

Air models were used to predict dust concentrations generated by dirt bike riders at the Olympia Nominee Trust Company and Wildwood Conservation Corporation properties and the concentration released from soil volatilization of organic compounds at the Wildwood Conservation Corporation property.

The air models require specification of numerous input parameters before execution. Site-specific data was used whenever possible for defining the values of the input parameters. However, various parameters, such as emission rates, had to be estimated, with the net result being either an over- or underestimation of the risks.

In addition, the inability of the air models to exactly duplicate the complex full-scale dispersion process results in discrepancies between modeled and measured concentrations at receptors. The model concentrations tend to overestimate the expected values from field measurements since the modeled values assume a constant wind speed and direction which will not be found in nature. Thus the air model results presented in this risk assessment should represent an upper bound for expected concentrations at receptors.

With respect to the exposure scenarios evaluated in this risk assessment, there are several uncertainties in determining the exposure parameters that will go into the scenario and that will ultimately be combined with toxicological information to assess risk. For example, there are a number of uncertainties regarding estimates of how often, if at all, an individual would come into contact with the chemicals of concern and the period of time over which such exposures would occur. For example, the Wildwood Conservation Corporation property was evaluated assuming the fence which currently surrounds the property did not exist. Thus, the exposures calculated in this assessment at the Wildwood Conservation Corporation property tend to overestimate actual conditions as they currently exist, but provide a measure of potential exposures should the fence not exist. In addition, other standard assumptions used throughout this assessment (e.g., ingestion of 2 liters of water a day, 70 kg average body weight, and 70 year lifetime), have been used when site-specific data are not available. Risks for certain individuals within an exposed population will be higher or lower depending on their actual drinking water intakes, body weights, and exposure.

Toxicological data are another source of uncertainties in this risk assessment. As EPA notes in its Guidelines for Carcinogenic Risk Assessment (EPA 1986b): There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There could be important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns and other cultural factors.

A particular problem is also presented by the necessity to perform risk assessments for polycyclic aromatic hydrocarbons (PAHs). PAHs occur in the environment as complex mixtures of many components. Only a few components of these mixtures have been adequately characterized, and only limited information is available on potential synergistic effects of the PAH mixture. The approach adopted by EPA (1980, 1984d) and used in this report as the basis for risk assessment is to divide the PAHs into two subclasses, "carcinogenic"

PAHs and "noncarcinogenic" PAHs, and to apply a cancer potency factor derived from oral bioassays on benzo[a]pyrene (B[a]P) to the subclass of carcinogenic PAHs. Most evidence indicates that benzo[a]pyrene is more potent than most of the other carcinogenic PAHs and a mixture of carcinogenic PAHs (Schmahl et al. 1977, Pfeiffer 1977). However, the relative cancer potency factor of mixtures of carcinogenic PAHs found at the Wells G & H site compared to that of B(a)P is unknown. It is unknown whether the risk assessment underestimates or overestimates the potential risk from exposure to PAHs.

There is also a great deal of uncertainty in assessing the toxicity of a mixture of chemicals. In this assessment, the effects of exposure to each of the contaminants present in the environmental media have initially been considered separately. However, these substances occur together at the site, and individuals may be exposed to mixtures of the chemicals. Prediction of how these mixtures of toxicants will interact must be based on an understanding of the mechanisms of such interactions. The interactions of the individual components of chemical mixtures may occur during absorption, distribution, metabolism, excretion, or activity at the receptor site. Individual compounds may interact chemically, yielding a new toxic component or causing a change in the biological availability of an existing component, or may interact by causing different effects at different receptor sites. Suitable data are not currently available to rigorously characterize the effects of chemical mixtures similar to those present at the Wells G & H site. Consequently, as recommended in EPA's Superfund Public Health Evaluation Manual (EPA 1986a) and in EPA's Guidelines for Health Risk Assessment of Chemical Mixtures (EPA 1986c), chemicals present at the Wells G & H site were assumed to act additively for chemicals with similar toxicity endpoints. Hazard indices for chemicals exhibiting noncarcinogenic effects were segregated for chemicals exhibiting similar toxicity endpoints when summation of all the CDI:RfD ratios exceeded unity. The potential for synergistic or antagonistic interactions among the chemicals are not considered.

Where possible in this risk assessment, the potential impacts of exposures of a particular population to chemicals of concern via more than one exposure medium have been considered. For example at the Olympia Nominee Trust Company of all the CDI:RfD ratios exceeded unity. The potential for synergistic or antagonistic interactions among the chemicals are not considered.

Where possible in this risk assessment, the potential impacts of exposures of a particular population to chemicals of concern via more than one exposure medium have been considered. For example at the Olympia Nominee Trust Company property and at the Wildwood Conservation Corporation property, exposures through contact with soil and inhalation of dust were evaluated, and the combined risks are discussed in the multimedia exposure subsection of the property related section. Additional potential risk for populations exposed to contaminants from sources other than the property being discussed has not been formally considered. This may underestimate the potential impacts on future populations exposed by all of these routes.

10.0 SUMMARY AND CONCLUSIONS

This endangerment assessment for the Wells G & H site is a baseline assessment, which evaluates potential impacts to human health and the environment in the absence of remedial action under both current- and future-use scenarios. The site was divided into six areas which were treated individually. The areas determined to be sources of contamination to the aquifer are properties belonging to: W.R. Grace and Company, New England Plastics Company, Olympia Nominee Trust, Unifirst Corporation, Wildwood Conservation Corporation. The sixth area evaluated is referred to as the central area and includes the area surrounding Wells G & H, the Aberjona river, and the wetlands. An evaluation of risk was performed for each area. This evaluation included selecting chemicals of potential concern on an area by area basis based on sampling of environmental media and toxicity considerations and examining possible exposures to human and environmental populations. The findings are summarized in Table 10-1 and below.

10.1 W. R. GRACE AND COMPANY

Chemicals of potential concern selected for the groundwater were bis(2-ethylhexyl)phthalate, 1,2-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride. No chemicals of potential concern were selected for the soils, surface water, or sediments.

Under current land-use conditions, there are no exposure pathways by which human receptors could potentially be exposed to site contaminants. Under future use conditions, exposure pathways related to groundwater use were considered assuming the land use changed to residential property. Average and plausible maximum exposure scenarios were developed for ingestion of groundwater and inhalation of volatiles released while showering. The conclusions are summarized as follows:

TABLE 10-1

SUMMARY TABLE OF ESTIMATED RISKS ASSOCIATED WITH EXPOSURE AT THE WELLS G & H SITE

LOCATION	RISK AVERAGE	RISK PLAUSIBLE MAXIMUM	HAZARD INDEX AVERAGE	HAZARD INDEX PLAUSIBLE MAXIMUM
W. R. Grace and Company				
Ingestion of Groundwater	2E-03	2E-01	<1 (0.2)	>1 (24)
Inhalation of Volatiles Released while Showering	4E-04	5E-02	<1 (0.2)	>1 (23)
New England Plastics Corporation				
Inhalation of Volatiles Released During Industrial Processes by Industrial Workers	1E-07	1E-06	<1 (0.007)	<1 (0.06)
Dermal Contact and Incidental Ingestion of Surface Soil by Industrial Workers	7E-08	4E-05	<1 (0.005)	<1 (0.7)
Inhalation of Volatiles Released from Soil by Industrial Workers	3E-13	1E-09	<1 (8E-09)	<1 (4E-05)
Future Exposure to Surface Soil	1E-08	8E-04	<1 (0.02)	>1 (4)
Future Inhalation of Volatiles Released from Soil	3E-12	1E-08	<1 (1E-08)	<1 (2E-04)
Future Ingestion of Groundwater	8E-05	5E-04	<1 (0.08)	<1 (0.5)
Future Inhalation of Volatiles Released While Showering	6E-06	3E-05	<1 (0.07)	<1 (0.4)
Olympia Nominee Trust Company				
Dermal Contact and Incidental Ingestion of Soil by Industrial Workers	5E-10	3E-06	<1 (0.002)	<1 (0.3)
Dermal Contact and Incidental Ingestion of Soil by Young Adults	2E-09	3E-06	<1 (0.01)	<1 (0.9)
Inhalation of Dust Generated While Dirtbike Riding	3E-08	5E-06	<1 (2E-05)	<1 (0.001)
Future Exposure to Surface Soil	2E-08	6E-05	<1 (0.009)	<1 (0.8)
Future Ingestion of Groundwater	4E-04	1E-03	<1 (0.2)	<1 (0.7)
Future Inhalation of Volatiles Released While Showering	9E-06	4E-04	<1 (0.02)	<1 (0.06)
Unifirst Corporation				
Future Ingestion of Groundwater	1E-03	4E-02	1	>1 (47)
Future Inhalation of Volatiles Released While Showering	3E-04	1E-02	<1 (0.9)	>1 (41)
Future Exposure to Surface Soil	8E-10	4E-08	<1 (8E-07)	<1 (4E-05)
Wildwood Conservation Corporation				
Dermal Contact and Incidental Ingestion of Soil				
- Surface Soil	7E-08	7E-05	<1 (0.02)	>1 (2)
- Northern Sludges	8E-07	5E-05	<1 (0.4)	>1 (12)
- Southern Sludges	2E-07	2E-05	<1 (0.3)	>1 (18)
Inhalation of Dust Generated While Dirtbike Riding				
- Surface Soil	1E-07	3E-05	<1 (0.002)	1
- Northern Sludges	5E-07	3E-05	<1 (0.004)	<1 (0.5)
- Southern Sludges	7E-08	3E-06	<1 (0.0005)	<1 (0.3)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2E-03 = 0.002).

TABLE 10-1 CONTINUED

SUMMARY TABLE OF ESTIMATED RISKS ASSOCIATED WITH EXPOSURE AT THE WELLS G & H SITE

LOCATION	RISK		HAZARD INDEX	
	AVERAGE	PLAUSIBLE MAXIMUM	AVERAGE	PLAUSIBLE MAXIMUM
Wildwood Conservation Corporation Continued				
Future Exposure to Surface Soil				
- Surface Soil	7E-07	2E-03	<1 (0.01)	>1 (3)
- Northern Sludges	8E-06	1E-03	<1 (0.3)	>1 (14)
- Southern Sludges	2E-06	4E-04	<1 (0.2)	>1 (20)
Future Inhalation of Volatiles Released from Soil				
- Surface Soil	3E-07	1E-04	<1 (0.0009)	<1 (0.8)
- Northern Sludges	1E-07	2E-04	<1 (0.002)	<1 (0.3)
- Southern Sludges	1E-09	1E-05	<1 (2E-06)	<1 (0.2)
Future Ingestion of Groundwater	8E-04	2E-01	<1 (0.2)	>1 (116)
Future Inhalation of Volatiles Released While Showering	2E-04	7E-02	<1 (0.08)	>1 (96)
Nonsource Area of Wells G&H				
Inhalation of Volatiles Released During Industrial Processes by Industrial Workers	2E-06	3E-05	<1 (0.1)	<1 (0.3)
Dermal Contact and Incidental Ingestion of Soil	2E-09	1E-07	<1 (0.03)	<1 (0.2)
Incidental Ingestion of Surface Water				
- Adults	4E-11	1E-08	<1 (2E-05)	<1 (8E-04)
- Children	2E-09	6E-08	<1 (0.001)	<1 (0.02)
Dermal Contact and Incidental Ingestion of Sediments				
- Adults	3E-07	4E-04	<1 (0.002)	<1 (0.09)
- Children	8E-07	2E-04	<1 (0.003)	<1 (0.02)
Future Ingestion of Groundwater	4E-05	3E-04	<1 (0.1)	1
Future Ingestion of Groundwater Containing Radionuclides				
- Gross Alpha Particles	--	--	>1 (3)	>1 (35)
- Gross Beta Particles				
- Strontium-90	--	--	<1 (0.6)	>1 (4)
- Tritium	--	--	<1 (3E-04)	<1 (0.002)
- Radium	--	--	<1 (0.2)	1
- Uranium	--	--	<1 (0.03)	<1 (0.05)
Future Inhalation of Volatiles Released While Showering	4E-06	3E-05	<1 (0.05)	<1 (0.6)

NOTE: Scientific notation (such as 2E-06) is a shorthand way of indicating decimal places, (i.e., the magnitude of the number). A negative exponent indicates that the decimal should be moved the specified number of places to the left (i.e., 2E-03 = 0.002).

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of $2x10^{-3}$ and $2x10^{-1}$ for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average case but exceeded 1 for the plausible maximum case.

- Inhalation of volatiles released from the groundwater while showering could result in $4x10^{-4}$ and $5x10^{-2}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average case but exceeded 1 for the plausible maximum case.

10.2 NEW ENGLAND PLASTICS CORPORATION

Soil chemicals of potential concern were acetone, bis(2-ethylhexyl)phthalate, cadmium, lead, methylene chloride, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene. The groundwater chemicals of potential concern were trans-1,2-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene.

Under current land-use conditions at the New England Plastics Corporation property, the principal exposure pathways by which human receptors could potentially be exposed to site contaminants were direct contact of industrial workers with surface soils, inhalation of volatiles released from soils, and inhalation of volatiles released from the process water. Average and plausible maximum exposure scenarios were developed this pathway. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed population. Human health risks were assessed based on these estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of workers to volatiles released from the water used in the production process could result in potential excess upper bound lifetime cancer risks of $1x10^{-7}$ for the average exposure case and $1x10^{-6}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of workers to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $7x10^{-8}$ for the average exposure case and $4x10^{-5}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of workers to volatiles released from contaminated soil could result in potential upperbound lifetime excess cancer risks of $3x10^{-13}$ and $1x10^{-9}$ for the average and plausible maximum exposure cases, respectively. The hazard indices are both less than one for the average and plausible maximum cases.

The exposure scenario described above would apply for future land-use conditions as well. In addition, exposure pathways related to residential soil exposure and to uses of the groundwater were considered. The groundwater uses included ingestion of groundwater and inhalation of volatile organic chemicals released while showering. Average and plausible maximum exposure scenarios were developed. The conclusions are as follows:

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of $1x10^{-8}$ for the average exposure case and $8x10^{-4}$ for the plausible maximum exposure case. Under the conditions of the average case, the ratios of the CDI:RfD are below one and the hazard index is below one. However, under the plausible maximum scenario, the hazard index exceeds one.

- Inhalation of volatiles released from contaminated soil could result in potential upperbound lifetime excess cancer risks of $3x10^{-12}$ for average exposure conditions and $1x10^{-8}$ for plausible maximum exposure conditions. The hazard indices were less than one for both the average and plausible maximum cases.

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of $8x10^{-5}$ and $5x10^{-4}$ for the average and plausible maximum cases, respectively. The hazard index was less than 1 for both the average and plausible maximum cases.

- Inhalation of volatiles released from the groundwater while showering could result in $6x10^{-6}$ and $3x10^{-5}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for both the average and plausible maximum cases.

10.3 OLYMPIA NOMINEE TRUST COMPANY

The soil chemicals of potential concern were chromium, 4,4'-DDT, lead, and the carcinogenic and noncarcinogenic PAHs. The groundwater chemicals of potential concern were arsenic, bis(2-ethylhexyl)phthalate, 1,1-dichloroethene, trans-1,2-dichloroethene, lead, manganese, tetrachloroethene, trichloroethene, and total xylenes.

Under current land-use conditions at the Olympia Nominee Trust Company property, the principal exposure pathways by which human receptors could potentially be exposed to site contaminants originated with the contaminated soils. Industrial workers could potentially be exposed to site contaminants by direct contact with surface soils. Young adults were assumed to use the property for recreational purposes. Exposure scenarios were developed for direct contact with soil which included dermal contact with and incidental absorption of soil and for the inhalation of dust generated while riding dirt bikes. Average and plausible maximum exposure scenarios were developed for this pathway. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed population. Human health risks were assessed based on these estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of workers to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $5x10^{-10}$ for the average exposure case and $3x10^{-6}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of young adults to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $2x10^{-9}$ for the average exposure case and $3x10^{-6}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are less than one and equal to one, respectively.

- Exposure of young adults through the inhalation of dust generated while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of 3×10^{-8} and 5×10^{-6} for the average and plausible maximum exposure cases, respectively. There appears to be a low probability of adverse health effects resulting from noncarcinogenic exposure since the hazard indices are less than one and equal to one for the average and plausible maximum exposure cases.

The exposure scenario described above would apply for future land-use conditions as well. In addition, exposure pathways related to residential soil exposure and to ingestion of the groundwater were considered. Average and plausible maximum exposure scenarios were developed. The conclusions are as follows:

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of 2×10^{-8} for the average exposure case and 6×10^{-5} for the plausible maximum exposure case. Under the conditions of both the average and plausible maximum cases, there appears to be a low probability of adverse health effects as the hazard indices are below one.

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of 4×10^{-4} and 1×10^{-3} for the average and plausible maximum cases, respectively. The hazard index is below one for both the average case and the plausible maximum case. Thus, there appears to be a low probability of adverse health effects.

- Inhalation of volatiles released from the groundwater while showering could result in 9×10^{-6} and 4×10^{-4} potential upper bound excess lifetime cancer risks for average and plausible maximum cases, respectively. The hazard index was less than 1 for both the average and plausible maximum cases.

10.4 UNIFIRST CORPORATION

The soil chemical of potential concern was tetrachloroethene. The groundwater chemicals of potential concern were 1,1-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, and trichloroethene.

Under current land-use conditions, there are no exposure pathways by which human receptors could potentially be exposed to site contaminants. Under future-use conditions, exposure pathways related to groundwater use and soil exposure were considered. Average and plausible maximum exposure scenarios were developed for ingestion of groundwater, inhalation of volatiles while showering, and direct contact with soil which included dermal absorption from and incidental ingestion of soil. The conclusions are summarized as follows:

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of $1x10^{-3}$ and $4x10^{-2}$ for the average and plausible maximum cases, respectively. The hazard index equaled 1 for the average case but exceeded 1 for the plausible maximum case.

- Inhalation of volatiles released from the groundwater while showering could result in $3x10^{-4}$ and $1x10^{-2}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average and greater than one for the plausible maximum cases.

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of $8x10^{-10}$ for the average exposure case and $4x10^{-8}$ for the plausible maximum exposure case. Under the conditions of both the average and plausible maximum cases, the hazard indices, for exposure to chemicals exhibiting noncarcinogenic effects, are below one.

10.5 WILDWOOD CONSERVATION CORPORATION

Soil and sludge chemicals of potential concern were acetone, bis(2-ethylhexyl)phthalate, cadmium, chlordane, chloroform, chromium, 4,4'-DDT, trans-1,2-dichloroethene, lead, methylene chloride, carcinogenic PAHs, noncarcinogenic PAHs, PCBs, pentachlorophenol, phenol, tetrachloroethene, toluene, trichloroethene, and xylene. The groundwater chemicals of potential concern were chloroform, trans-1,2-dichloroethene, 1,2-dichlorobenzene, manganese, tetrachloroethene, 1,1,1-trichloroethane, trichloroethene, vinyl chloride, and xylene.

Under current land-use conditions at the Wildwood Conservation Corporation property, the principal exposure pathway by which human receptors could potentially be exposed to site contaminants was direct contact with surface soils and sludges by young adults using the property for recreational uses and inhalation of contaminated air released from these same sources. Average and plausible maximum exposure scenarios were developed for this pathway. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed population. Human health risks were assessed based on these estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of young adults to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $7x10^{-8}$ for the average exposure case and $7x10^{-5}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of average exposure, as the hazard index is less than one. Under conditions of plausible maximum exposure, there is a probability of adverse health effects as the hazard index exceeds one.

- Exposure of young adults to northern sludges through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $8x10^{-7}$ for the average exposure case and $5x10^{-5}$ for the plausible maximum exposure case. Exposure of young adults to southern sludges through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $2x10^{-7}$ for the average exposure case and $2x10^{-5}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects for both the northern and southern sludges appears to present a low probability of adverse health effects based on the conditions of average exposure, as the hazard index is less than one. The hazard index exceeds one for plausible maximum exposure.

- Exposure of young adults through the inhalation of dust and volatile organics generated from surface soils while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of $1x10^{-7}$ and $3x10^{-5}$ for the average and plausible maximum exposure cases, respectively. Exposure of young adults through the inhalation of dust and volatile organics generated from northern sludges while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of $5x10^{-7}$ and $3x10^{-5}$ for the average and plausible maximum exposure cases, respectively. Exposure of young adults through the inhalation of dust and volatile organics generated from southern sludges while riding dirt bikes could result in potential excess upper bound lifetime cancer risks of $7x10^{-8}$ and $3x10^{-6}$ for the average and plausible maximum exposure cases, respectively. There appears to be a low probability of adverse health effects resulting from noncarcinogenic exposure to air contamination generated from surface soils, northern sludges, and southern sludges since the hazard indices are less than or equal to one for the average and plausible maximum exposure cases.

The exposure scenario described above would apply for future land-use conditions as well. In addition, exposure pathways related to residential soil exposure and to uses of the groundwater were considered. The groundwater uses included ingestion of groundwater and inhalation of volatile organic chemicals released while showering. Average and plausible maximum exposure scenarios were developed. The conclusions are as follows:

- Exposure of residents to surface soil could result in upper bound excess lifetime cancer risks of $7x10^{-7}$ for the average exposure case and $2x10^{-3}$ for the plausible maximum exposure case. The hazard indices for the average and plausible maximum cases were below one and slightly greater than one. For the northern sludges, the upper bound excess lifetime cancer risks from average and plausible maximum exposures were $8x10^{-6}$ and $1x10^{-3}$, respectively. The upper bound excess lifetime cancer risks from exposure to the southern sludges were $2x10^{-6}$ and $4x10^{-4}$ for the average and plausible maximum cases, respectively. For both the northern and southern sludges, under the conditions of the average case, the ratios of the CDI:RfD are below one and the hazard index is below one. However, under the plausible maximum scenarios, the hazard index exceeds one.

- Exposure of residents through the inhalation of volatile organic compounds released from surface soils could result in upper bound excess lifetime cancer risks of $3x10^{-7}$ and $1x10^{-4}$ under average and plausible maximum exposure conditions, respectively. The upper bound excess cancer risk from inhalation of volatiles released form the northern sludges are $1x10^{-7}$ for the average case and $2x10^{-4}$ for the plausible maximum case. For the southern sludges, the upper bound excess lifetime cancer risks for the average and plausible maximum cases are $1x10^{-9}$ and $1x10^{-5}$, respectively. The hazard indices for the soil and sludges under the average and plausible maximum cases are less than one.

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of $8x10^{-4}$ and $2x10^{-1}$ for the average and plausible maximum cases, respectively. The hazard index was less than one for the average case and exceeded one for the plausible maximum case.

- Inhalation of volatiles released from the groundwater while showering could result in $2x10^{-4}$ and $7x10^{-2}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively.

The hazard index was less than 1 for the average case and exceeded one for the plausible maximum case.

10.6 CENTRAL AREA OF THE WELLS G & H SITE

The soil chemicals of potential concern selected were cadmium, chlordane, lead, and pyrene. The groundwater chemicals of potential concern were barium, trans-1,2-dichloroethene, radionuclides (gross alpha and gross beta particles, radium, and uranium), tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene. The chemicals of potential concern for surface water were bis(2-ethylhexyl)phthalate, trans-1,2-dichloroethene, lead, tetrachloroethene, and trichloroethene. The sediment chemicals of concern were acetone, aldrin, arsenic, bis(2-ethylhexyl)phthalate, cadmium, chromium, copper, mercury, methylene chloride, carcinogenic PAHs, noncarcinogenic PAHs, and zinc.

Under current land-use conditions, the exposure pathways by which human receptors could potentially be exposed to site contaminants involve direct contact with soils, surface water, and sediment. Average and plausible maximum exposure scenarios were developed. The exposure point concentrations of the chemicals of potential concern were estimated for the potentially exposed populations. Human health risks were assessed based on estimates of exposure and a quantitative description of each compound's toxicity. The major conclusions can be summarized as follows:

- Exposure of workers at the Riley Tannery to volatile released from water used in the production process could result in potential excess upper bound lifetime cancer risks of $2x10^{-6}$ for the average exposure case and $3x10^{-5}$ for the plausible maximum case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are both less than one.

- Exposure of individuals to surface soil through dermal contact and incidental ingestion could result in potential excess upper bound lifetime cancer risks of $2x10^{-9}$ for the average exposure case and $1x10^{-7}$ for the plausible maximum exposure case. Exposure to the chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of both average and plausible maximum exposure, as the hazard indices are less than one.

- Exposure of adults trapping in the Aberjona River to surface water could result in potential upper bound excess cancer risks of $4x10^{-11}$ and $1x10^{-8}$ under average and plausible maximum exposure conditions, respectively. Exposure of this same population to sediments could result in potential upper bound excess cancer risks of $3x10^{-7}$ under average conditions and $4x10^{-4}$ under plausible maximum exposure conditions. The hazard indices were less than one for exposure to both surface water and sediments under average and plausible maximum conditions.

- Exposure to children playing the Aberjona River to surface water could result in potential upper bound excess cancer risks of $2x10^{-9}$ under average conditions and $6x10^{-8}$ under plausible maximum exposure conditions. Exposure of this same population to sediments could result in potential upper bound excess cancer risks of $8x10^{-7}$ and $2x10^{-4}$ under average and plausible maximum exposure cases, respectively. The hazard indices were less than one for exposure to both surface water and sediment for average and plausible maximum cases.

The exposure scenarios described above would apply for future land use conditions as well. In addition, exposure pathways related to groundwater use was considered. Average and plausible maximum exposure scenarios were developed for ingestion of groundwater and inhalation of volatiles while showering. The conclusions are summarized as follows:

- Ingestion of groundwater could result in potential upper bound lifetime excess cancer risks of $4x10^{-4}$ and $5x10^{-3}$ for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average case but equaled 1 for the plausible maximum case.

- Ingestion of groundwater containing radionuclides could result in exposures greater than the recommended 4 mrem/year dose. The geometric mean and maximum concentrations of the gross alpha particles exceeded this reference level. The maximum gross beta particle (as strontium-90) and radium concentrations exceeded the concentration corresponding to a 4 mrem/year dose. If the gross beta particles were present only as tritium then the concentrations were well below the 4 mrem/year level. The geometric mean and maximum uranium concentrations were less than the concentration corresponding to a 4 mrem/year dose.

- Inhalation of volatiles released from the groundwater while showering could result in $4x10^{-6}$ and $3x10^{-5}$ potential upper bound excess lifetime cancer risk for the average and plausible maximum cases, respectively. The hazard index was less than 1 for the average and plausible maximum cases.

10.7 ECOLOGICAL RECEPTORS

Potential risks to environmental receptors have been evaluated based on the results of site monitoring data, a review of the toxicity of the chemicals of concern, and estimates of exposure. The assumptions used in estimating exposures and deriving toxicity reference values have been described in this assessment. The results of this environmental risk assessment are summarized below.

Aquatic life may be at risk from exposure to aluminum, iron, lead, and three phthalates (bis(2-ethylhexyl)-, butylbenzyl-, and di-n-octyl phthalate) in surface water. Concentrations reported at the site and downstream exceeded chronic AWQCs. The concentrations of aluminum and iron, however, are unlikely to have resulted from site-related anthropogenic inputs. The presence of the phthalates could be due to laboratory contamination rather than due to site-related activities. All of the contaminants in surface water were detected at concentrations associated with chronic rather than acute toxicity.

The maximum concentration of copper reported in the site sediments exceeds laboratory LC_{50} concentrations for several invertebrate species. Levels of arsenic, chromium, and zinc were elevated above background but conclusions cannot be drawn due to a lack of data linking sediment concentrations with effects. Qualitative field observations of decreases in abundance and diversity of aquatic invertebrates also suggest adverse conditions for aquatic life.

Waterfowl in the Aberjona River and marsh areas may obtain contaminants through their consumption of aquatic invertebrates. The ingestion of lead that has been bioconcentrated by invertebrates does not appear to pose a substantial risk to ducks. No conclusions can be made on the risks to waterfowl from ingestion of contaminated invertebrates in the absence of body burden data for either invertebrates or waterfowl.

Terrestrial birds and mammals can obtain contaminants by drinking surface water at the site. However, the levels of contaminants obtained through this route are much lower than known toxic levels, and significant risks are not expected from this route of exposure.

Some species of birds, such as woodcocks which feed predominantly on earthworms, may obtain potentially hazardous doses DDT and PCBs. The persistence of DDTr and PCBs in terrestrial ecosystems is cause for concern that predators and scavengers may also be adversely affected.

Mammals such as the shrew, which also consume large number of earthworms, may be at risk. Chlordane, DDTr, PAHs and PCBs are the chemicals of concern. These substances are known to cause chronic toxic effects in laboratory rodents. In most cases, estimated doses exceeded toxicity reference values by at least a factor of 10.

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